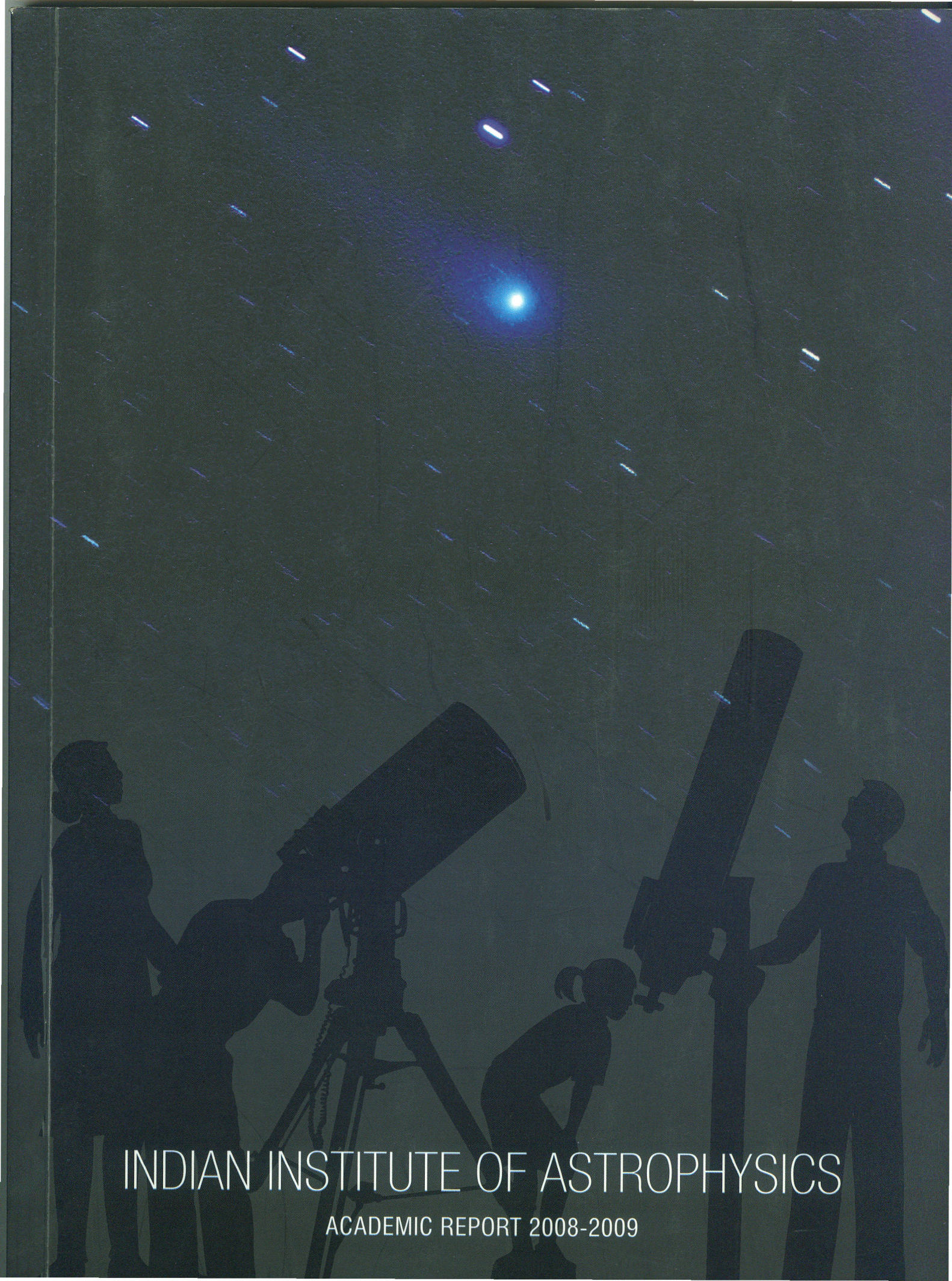
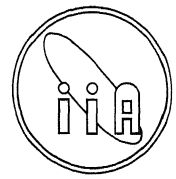


INDIAN INSTITUTE OF ASTROPHYSICS

ACADEMIC REPORT 2008-2009



INDIAN INSTITUTE OF ASTROPHYSICS

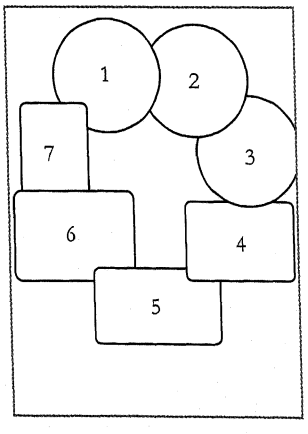
ACADEMIC REPORT

2008-09

Edited by: Prajval Shastri and S.P. Rajaguru
Editorial Assistance: Sandra Rajiva
Technical Expertise: Baba Varghese
Published on behalf of: The Director, Indian Institute of Astrophysics, Sarjapura Road, Bengaluru 560 034. INDIA

Front cover Astrophotograph: Comet Lulin, which was visible to the human eye in February, 2009, photographed at the Vainu Bappu Observatory. *Image credits:* K Kuppuswamy, P Anbazhagan, M Muniraj & R Ganesan.

Inside back cover: Astronomy tableau at the Republic Day parade, January 26, 2009, New Delhi.
Image credit: Balagopal & Bibhuti Events & Expositions Pvt. Ltd.



Back cover:

1-3. Researchers at work

4. Sun-viewing by school children at IIA on Science Day, February 28, 2009

5. A scene from the play *Starry Messenger*, ASI 2009

6. School children attending an astronomy lecture at IIA

7. Illustration of Galileo's experiment by T. Ashwin, Government High School, Madivaala. Bengaluru

Image credits:

1-3. Pervez Rajan, 4. S.P. Rajaguru, 5. V.S. Shyam, 6. Prajval Shastri.

Printed and processed by: Vykat Prints Pvt. Ltd.
Cover design and illustration by: Pervez Rajan

Contents

Governing Council

Dr K. Kasturirangan (Chair)
Member (Science), Planning Commission
Yojana Bhavan, New Delhi 110 001
k.rangan@nic.in

Dr T. Ramasami Member (ex-officio)
Secretary
Department of Science & Technology
New Delhi 110 016
dstsec@nic.in

Shri K. P. Pandian Member (ex-officio)
Jt. Secretary & Fin. Adviser
Department of Science & Technology
New Delhi 110 016
kp_pandian@hotmail.com

Professor P. C. Agrawal Member
ISRO-Chair Professor
TIFR, Mumbai 400 005
prahlad.agrawal@gmail.com

Professor S. M. Chitre Member
Centre for Excellence in Basic Sciences
University of Mumbai
Kalina, Santa Cruz East
Mumbai 400 098
kumarchitre@gmail.com

Professor P. Khare Member
Dept. of Physics, Utkal University
Bhubaneswar 751 005
pushpakhare@gmail.com

Professor H. S. Mani Member
IISER Mohali
MGSIPA Campus, Sector 26
Chandigarh 160 019
hsmani@gmail.com

Professor N. Mukunda Member
Vice-President
Indian Academy of Sciences
Bangalore 560 080
nmukunda@gmail.com

Professor J. V. Narlikar Member
Emeritus Professor
IUCAA
Pune 411 007
jvn@iucaa.ernet.in

Professor Ram Sagar Member (ex-officio)
Director, ARIES
Nainital 263 129
sagar@aries.ernet.in

Professor B. C. Sinha Member
Homi Bhabha Chair Professor
Variable Energy Cyclotron Centre
Kolkata 700 064
bikash@veccal.ernet.in

Professor R. Subrahmanyan Member (ex-officio)
Director, RRI
Bangalore 560 080
rsubrahm@rri.res.in

Professor S. S. Hasan Member Secretary (Ex-Officio)
Director, IIA
Bangalore 560 034
hasan@iiap.res.in

Honorary Fellows

Professor M. G. K. Menon, FRS
C-178, Sarvodaya Enclave, New Delhi 110 017

Professor P. Buford Price
Physics Department, University California, Berkeley, USA

Professor V. Radhakrishnan
Raman Research Institute, Bangalore 560 080

Professor D. L. Lambert
Department of Astronomy, University of Texas, Austin, USA

Professor S. Chandrasekhar, Nobel Laureate (1995)

Professor R. M. Walker (2004)

Professor Hermann Bondi, FRS (2005)

---

†*deceased*

THE YEAR IN REVIEW

It gives me great pleasure to present the highlights of the Institute's activities during the current year, covering its research, development, teaching programmes and public outreach. IIA continues to be at the forefront in the creation of new world-class facilities as well as in training a new generation of young researchers in the astrophysical sciences.

On the research front, there have been several noteworthy results obtained by IIA scientists. In solar physics, an efficient mechanism has been identified for heating the chromosphere and corona through the dissipation of magnetohydrodynamic waves in the magnetic network of solar and stellar atmospheres. Using space observations from SOHO (Solar and Heliospheric Observatory) and Hinode (a Japanese solar satellite), long period oscillations (10-30 min.) have been detected in polar coronal holes. These waves are likely to play an important role in acceleration of the fast solar wind. An analysis of X-ray bright points from Hinode points to a high variability in their temperature. A local helioseismic study of sunspots has added valuable information on the nature of near-surface magnetic effects and the detectability of deeper residing structural changes. Other interesting research include studies of the Hanle effect, polarised spectral lines, meridional flows and solar cycle prediction, coronal rotation, active regions and the use of gravity modes as probes of the rotation of the solar core.

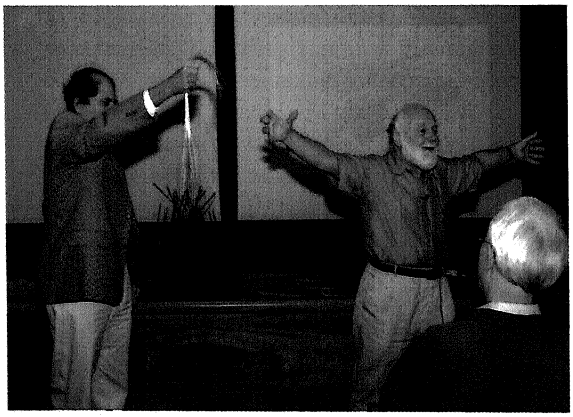
In the area of planetary sciences, data from the Deep Impact NASA probe of comet Tempel 1 have been analyzed. By combining observations from the 2-m Hanle Chandra Telescope (HCT) and theoretical models of jets from the comet, several important implications were deduced, particularly concerning the effects of the physics of sublimation and diffusion in comets. New calculations have predicted that scattering by clouds in the atmosphere of extrasolar planets would polarize light from these planets. Hence polarized light from such objects could provide a diagnostic for detecting earth-like planets outside the solar system.

An important result in stellar physics is related to a comprehensive study of supernova SN 2005hk. For the first time, it follows the photometric and spectral evolution of this class of supernovae during the early as well as the nebular phases. The supernova has been found to be underluminous compared to normal type Ia supernovae. This finding is valuable for the study of the homogeneity and heterogeneity of type 1a supernovae, the standard candle in cosmology. The majority of the stars in the Sun's immediate neighbourhood belong to a thin disk with a scale height of 300 pc, and a minority comes from a thick disk component having a scale height of 1350 pc. An extensive search for metal-weak thick disk stars with reliable kinematics and metallicities has been carried out. A comprehensive abundance analysis has been undertaken for metal-weak thick disk candidates and halo stars in order to search for definitive differences in composition between candidate metal-weak thick disk stars and halo stars of similar metallicity. It is gratifying to note that the data obtained from the telescopes at Kavalur and Hanle form a significant basis of the above studies.

Star formation, composition, stellar structure and evolution continue to be the core research interests of a large number of IIA scientists. Evidence for triggered widespread star-formation has been found in a large HII region of the Milky Way. The near and far-ultraviolet diffuse background has been found to be due to a combination of H2 fluorescence and scattering by interstellar dust, in addition to airglow and zodiacal light. Starspots have been found to be responsible for rotational modulation of the intensity in a RS CVn binary star. The mysterious Li rich K giants have been found to be very rare objects and only about 1% of the disk population in the Galaxy. The emission beams of pulsars have been found to have a nested core-cone structure. Also, an important extensive investigation of stars in the thick disk of the Milky Way has been initiated, by kinematically selecting thick disk candidates. In the area of extragalactic physics, the bar of the Large Magellanic Cloud has been confirmed to be very much part of its disk. A galaxy with interplay between a nuclear starburst and an active super massive black hole has been found at a redshift of 3.9. Evidence for helical

magnetic fields has been found at the launching sites of jets in radio galaxies of the low-power flaring type. The evolution of intermediate-mass black holes has been studied. Observed properties of Seyfert galaxies are found to be consistent with the unification scheme. The global decrease in stellar density with cosmological epoch changes the gas accretion mode around supermassive black holes found in the nuclei of galaxies, resulting in a spin-down of the black hole.

Computational research of molecules and atoms, as well as research in optics that feeds into IIA's efforts in adaptive optics have also continued with vigour. Interestingly, a new limit has been obtained for the electric dipole moment of the electron in thallium. Further, the 'improved virtual orbitals' method applied to isomers of 1,2–difluoro- and chloroethene imply that the *cis*-isomers are energetically more stable than the corresponding trans-isomers, consistent with experimental results.

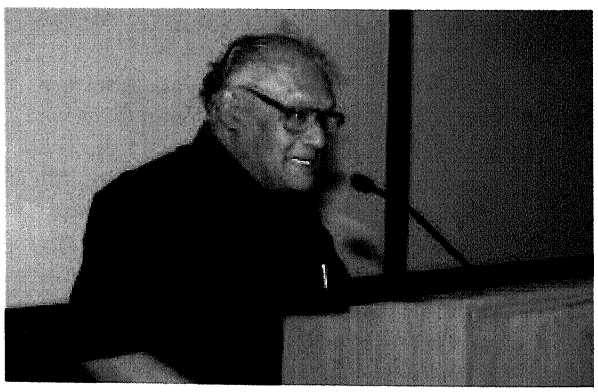


Professor Douglas Gough demonstrating the behaviour of magnetic field lines

A major new initiative taken by the Institute in the current Plan has been to propose a state-of-the-art 2-m class National Large Solar Telescope (NLST). This will be the largest one of its kind in the world for several years. Site characterization studies are underway to identify a suitable location for this facility. Concurrently, a detailed comprehensive concept design report is under preparation, which will be finalised soon. IIA is also a major partner in a collaborative project with ISRO and other national institutions to indigenously develop a visible emission line solar coronagraph. Another major initiative that IIA has taken, jointly with ARIES, IUCAA and RRI, is to prepare a detailed project report concerning India's participation in one of the international Giant Segmented Mirror Telescopes.

The challenging task of development and fabrication of the Ultra-Violet Imaging Telescope (UVIT) has progressed considerably. The detector systems have arrived at the Institute and are being tested in the recently commissioned M.G.K. Menon Laboratory for Space Sciences at Hosakote. Fabrication of several components is complete. This telescope will be a payload aboard the first Indian satellite dedicated for astronomy, ASTROSAT, to be launched by ISRO during 2010. The Indo-Israel ultraviolet telescope TAUVEX, recently delivered to ISRO, is due for launch towards the end of 2009. The Institute is responsible in mission planning, development of the software pipeline and science tools. The 1.3-m Ritchy-Chretien optical telescope for the Vainu Bappu Observatory (VBO), expected to serve the needs of wide field imaging, is getting ready at DFM Engineering in the USA. Elaborate preparations were made for the design and fabrication of instruments to carry out experiments during the total solar eclipse of July 22, 2009 from sites in China and India.

Upgradation and development of the research facilities at all of IIA's field stations have progressed steadily, including the installation of an auto-guider for the high-resolution echelle spectrograph at the Vainu Bappu Telescope. The Himalayan Gamma Ray Telescope (HAGAR) has become operational and begun regular observations of the Crab Nebula and Geminga pulsar from September 2008. Preliminary results on the Crab Nebula, using this telescope, have shown a trigger rate of about 14 Hz with a gamma ray signal above 185 GeV. Continuous efforts are being made to achieve greater efficiency and lower the energy threshold to about 100 GeV to exploit the advantages of the high altitude site at Hanle.

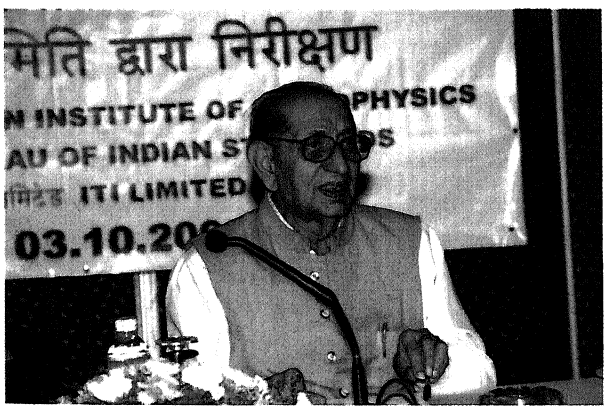


Professor C.N.R. Rao delivering the Founder's Day Lecture

The Institute commemorated the centenary of the Evershed effect, a major discovery made in solar

physics at Kodaikanal 1909, by organizing an international conference on 'Magnetic coupling between the interior and the atmosphere of the Sun' in December 2008. The meeting attracted a large number of leading experts in the study of the Sun from all over the world, and provided a forum to present and discuss the state-of-the-art results on all aspects of solar magnetism. Douglas Gough, Leverhulme Emeritus Fellow from the University of Cambridge, U.K. delivered an enthralling Vainu Bappu Memorial Lecture, the second in the series, on 'What is a Sunspot?' The Department of Posts specially brought out a commemorative postal stamp and First Day Cover for this event.

On the human resources front, the Institute has recently launched two new major programmes with the aim of creating a pool of young scientists and engineers trained in the field of astronomy and astrophysics. Jointly with IGNOU and Calcutta University, IIA has commenced Integrated Ph.D. programmes in the physical sciences and astronomy instrumentation respectively. Since last year, the Institute has doubled its intake of students in various branches of astronomical sciences. Similarly an active programme for inducting post-doctoral fellows is underway in the Institute. A prestigious post-doctoral fellowship, named after Professor S. Chandrasekhar, was set up last year with a view to encourage brilliant young scientists to work at the Institute. The first Chandra Fellow, Dr. Savita Mathur from Saclay, France joined in October 2008. Similar to last year, four graduate students from U.S.A. visited IIA to carry out research projects with Institute faculty under the International Research Experience for Students (IRES) programme, sponsored by the National Science Foundation of U.S.A.

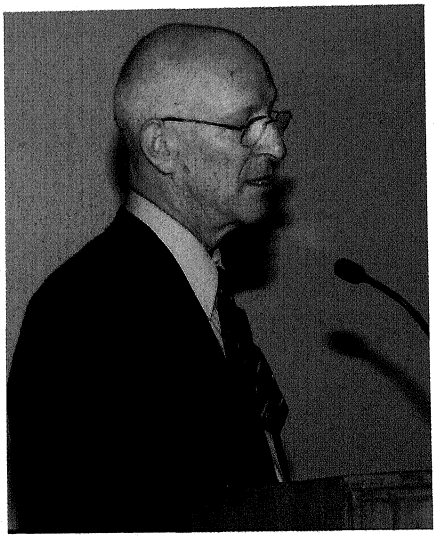


Hon'ble Dr. Laxmi Narayan Pandey, who led the visit of the second sub-committee of the Committee of Parliament on Official Language implementation.

The United Nations declared 2009 as the International Year of Astronomy (IYA). As part of IYA, a major initiative taken by IIA was to conceptualize and present a tableau, on behalf of the Department of Science and Technology, Govt. of India, for the Republic Day Parade on January 26, 2009. The tableau highlighted the achievements of Indian astronomers, and was widely appreciated by the general public. Furthermore, the Institute has designed and fabricated an optical telescope with an aperture of 10 cm for distribution to educational institutions and various science centres across the country. A '100-lecture series' of popular-level astrophysics countrywide lectures has been initiated. A highlight was the commissioning of a play by the Institute on the life of Galileo Galilei, which was premiered at the Astronomical Society of India meeting hosted by IIA at its Bangalore campus in February 2009.

Jan Stenflo, Vainu Bappu Visiting Professor

The Institute conducted various national and international schools and workshops at the stimulating environment of Kodaikanal Observatory and VBO, Kavalur. Such meetings provide rare opportunities for developing new collaborative studies and intent discussions on current topics in astronomy and astrophysics. One of these was an inter-disciplinary Astrostatistics School, the 2nd in the series, in collaboration with Pennsylvania State University, USA during July 2009. Another meeting organized by IIA was on 'Recent advances in Spectroscopy' at Kodaikanal in January 2009 where theorists, observers and laboratory astrophysicists gathered to debate on a number of cutting-edge inter-disciplinary problems in this area.



Claude Nicollier, Swiss astronaut, giving a popular talk on his experiences in space

Several national and international distinguished scientists visited the Institute and interacted with its members for collaborative research. Professor C.N.R. Rao delivered the 2nd Founders Day Lecture on 'Doing Science in India: Personal reminiscences'. Professor J. O. Stenflo, renowned solar physicist and Emeritus Professor, Swiss Federal Institute of Technology (ETH), Zurich, visited the Institute during December, 2008 as the first Vainu Bappu Visiting Professor. Dr. Claude Nicollier, a Swiss astronaut, who flew on several NASA missions including the Hubble Space Telescope repair mission, gave a fascinating popular talk at the Institute on his experiences from space.

Inauguration of Bhaskara by T. Ramasami, Secretary, DST.

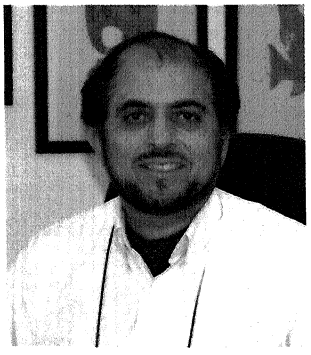
Turning to infrastructure development, I am happy to announce the completion of a new modern and well-equipped hostel and guest house named *Bhaskara*, that was inaugurated on November 16, 2008 by Dr. T. Ramasami, Secretary, Department of Science and Technology. *Bhaskara*, a short walk from the main campus, has 45 rooms and accommodates IIA students, as well as post-doctoral fellows and visiting scientists.

Over the years, the Institute has been playing host to the visits of various Parliamentary Standing Committees. In October 2008, the second sub-committee of the Committee of Parliament on Official Language implementation, led by Hon'ble Dr. Laxmi Narayan Pandey visited the Institute. The Honourable Committee appreciated the efforts of the Institute in the implementation of the official language at IIA.

The Institute continues to play a constructive and important role in safeguarding the interests of SCs and STs as well as to promote gender amity in the work place.

Before concluding my report, I would like to offer my felicitations to my colleagues who have been recognised by national and international professional bodies for their seminal scientific contributions. Dr. M. Sampoorna, an IIA student, was among the outstanding young scientists chosen by the Government of India to participate in a meeting with Nobel Laureates in Lindau, Germany. Furthermore, members from the Institute have been invited to serve on international advisory committees, offered honorary positions at various prestigious national and international institutions, elected to Commissions of the International Astronomical Union and editorial boards of international journals.

S. S. Hasan
Director



Chapter 1

Research

1.1 Solar Physics

Hanle effect in a random magnetic field

The Hanle effect is used to determine weak turbulent magnetic fields in the solar atmosphere, traditionally assuming that the distribution is isotropic, field strength is constant and that micro-turbulence holds. In order to examine the sensitivity of turbulent magnetic field to these assumptions, the dependences of Hanle effect on the magnetic field correlation length, its angular and strength distributions are studied.

Key results: (1) A fairly general random magnetic field model characterized by a 'correlation length' and a 'magnetic field vector distribution' is introduced. Micro-turbulence is recovered when the correlation length goes to zero and macro-turbulence when it goes to infinity. Radiative transfer equations are established for the calculation of mean Stokes parameters and are solved numerically by a Polarized Approximate Lambda Iteration method. (2) Optically thin and very thick spectral lines are insensitive to the correlation length of the magnetic field while spectral lines with intermediate optical depths ($\approx 10 - 100$) show some sensitivity. Thus, micro-turbulence is in general a 'safe approximation'. (3) The dependence of polarization on the magnetic field vector Probability Density Function (PDF) is examined in the micro-turbulent limit. A few PDFs with different angular and strength distributions, but equal mean value of the magnetic field, are considered. It is found that the polarization is in general sensitive to the shape of the magnetic field strength PDF and to the angular distribution. (See Fig. 1.1). Thus the mean field derived from Hanle effect analysis of polarimetric data strongly depends on the choice of field strength distribution used in the analysis.

(H. Frisch, L. S. Anusha, M. Sampoorna, & K. N. Nagendra)*

*Collaborators from other institutions

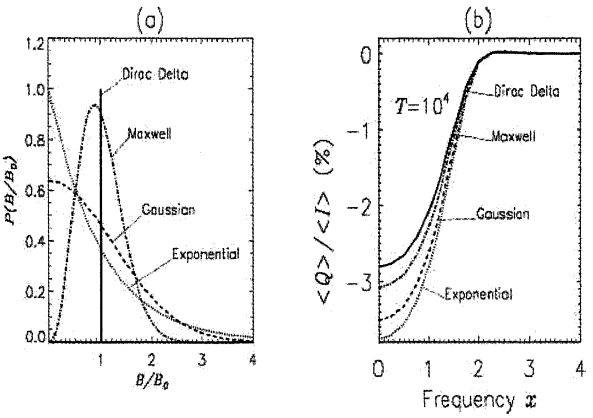


Figure 1.1: Panel (a) : various PDFs as a function of turbulent field strength in units of mean field B_0. Panel (b) : the emergent $\langle Q \rangle / \langle I \rangle$ profile for $\mu = 0.05$.

Origin of spatial variations of scattering polarization in the wings of the Ca I 4227 Å line

Solar line polarization produced by coherent scattering can be modified by magnetic fields via the Hanle effect. This has opened up a window to explorations of solar magnetism in parameter domains not accessible to the Zeeman effect. According to the standard theory, the Hanle effect should only be operating in the Doppler core of spectral lines but not in the wings. In contrast, our own observations of the scattering polarization in the Ca I 4227 Å line reveals the existence of spatial variations of the scattering polarization throughout the far line wings. This raises the question whether the observed spatial variations in wing polarization have a magnetic or non-magnetic origin ? A magnetic origin may be possible if elastic collisions are able to cause sufficient frequency redistribution to make the Hanle scattering effective in the wings without causing excessive collisional depolarization, as suggested by recent theories for partial frequency redistribution (PRD) in magnetic fields.

Key results: (1) To model the wing polarization, an extended version of the technique based on the "last scattering approximation" (LSA) is applied. It assumes that the polarization of the emergent radiation is determined by the anisotropy of the incident radiation field at the last scattering event. This anisotropy is determined from the 'observed limb darkening as a function of wavelength' throughout the spectral line. The empirical anisotropy profile is used together with the single-scattering redistribution matrix, which contains all the PRD, collisional, and magnetic-field effects. The model further contains a continuum opacity parameter, which increasingly dilutes the polarized line photons as one moves away from the line center, and a continuum polarization parameter that represents the observed polarization level far from the line. (2) This model is highly successful in reproducing the observed Stokes Q/I polarization (linear polarization parallel to the nearest solar limb), including the location of the wing polarization maxima and the minima around the Doppler core, (See Fig. 1.2), as seen in the figure, but it fails to reproduce the observed spatial variations of the wing polarization in terms of magnetic field effects with frequency redistribution. This null result points in the direction of a non-magnetic origin in terms of local inhomogeneities (varying collisional depolarization, radiation-field anisotropies, and deviations from a plane-parallel atmospheric stratification).

(M. Sampoorna, J. O. Stenflo , K. N. Nagendra, M. Bianda,* R. Ramelli,* & L. S. Anusha)*

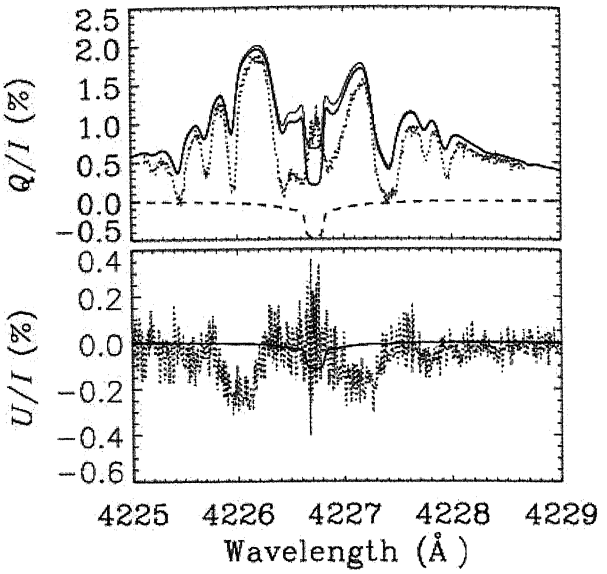


Figure 1.2: The dotted line shows the observations in a weak magnetic field. In the Q/I panel the heavy solid line represents the magnetic model profile, the thin solid line the non-magnetic model profile, and the dashed line their difference. Note how well the observed Q/I wings are fitted by the computed model profile. In the U/I panel the solid line represents the magnetic model profile. The parameters used are $(\Gamma_B, \vartheta_B, \varphi_B; \Gamma_E/\Gamma_R) = (10, 90°, 135°; 10)$.

Hanle effect with partial frequency redistribution

The Hanle effect has a good diagnostic potential to measure weak directed fields, as proved in the case of prominences, or canopy like chromospheric structures, and turbulent magnetic fields. The analysis of Hanle scattering polarization in the polarized line spectrum of the Sun requires the solution of a radiative transfer equation in which the scattering term involves a redistribution matrix that describes the correlation in frequency, angle and polarization between the incoming and outgoing radiation. Taking into account properly these partial frequency redistribution (PRD) effects are of fundamental importance to interpret the polarization of resonance lines. The examples are: Ca I 4227 Å line, and the Ca II H and K lines.

The Polarized Approximate Lambda Iteration technique, PALI6, developed before for the weak field Hanle effect relies on the decomposition of the Stokes parameters I, Q and U into six cylindrically symmetrical components. This method is applied to complete and partial frequency redistribution with redistribution matrices in which frequency changes are decoupled from scattering polarization. For PRD, the decoupling is obtained by an adequate decomposition of the frequency space into several domains. By a new angle-averaging procedure, a redistribution matrix which keeps coupling between frequency redistribution and polarization without recourse to domain decomposition, is constructed. The coupling is contained in 'generalized frequency redistribution functions' that depend on the magnetic field. The redistribution matrix is expanded in terms of the spherical tensors for polarimetry $\mathcal{T}^K_Q$ and the Stokes parameters are decomposed into cylindrically symmetrical components. A PALI method is set up for the calculation of these components. It is shown that the frequency space decomposition may induce large errors on Stokes U in the transition region between line core and line wings but can safely be used for Stokes I and Q, the errors staying less than 1% at all the frequencies. See plot. (See Fig. 1.3).

(M. Sampoorna, K. N. Nagendra & H. Frisch)*

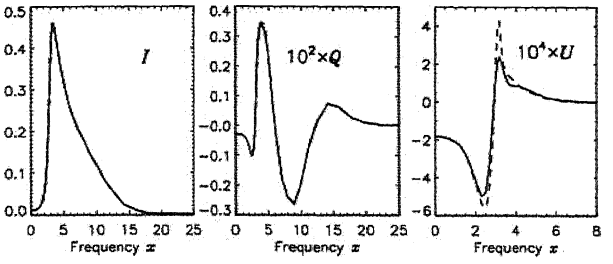


Figure 1.3: Comparison of two numerical methods. The emergent Stokes parameters for the direction $\mu = 0.11$ and $\varphi = 0°$ computed using the PALI7 (solid line), and the PALI6 (dashed line) methods. An isothermal self-emitting slab with the model parameters $(T, a, \epsilon, r, \Gamma_E/\Gamma_R) = (2 \times 10^6, 10^{-3}, 10^{-4}, 0, 0)$, where Γ_E is the elastic collision rate are used. The magnetic field parameters are $(\Gamma_B, \vartheta_B, \varphi_B) = (1, 30°, 0°)$, where $\Gamma_B = geB/(2mc\Gamma_R)$ in standard notation, and (ϑ_B, φ_B) define field orientation with respect to the atmospheric normal.

Magnetostatic structures in the partially ionized solar atmosphere

The lower solar atmosphere is a partially ionized plasma consisting of electrons, ions and neutral hydrogen atoms. In this essentially a three-fluid system the Hall effect arises from the treatment of electrons and protons as two separate fluids and the ambipolar diffusion due to the inclusion of neutrals as the third fluid. The Hall effect and the ambipolar diffusion have been shown to be operational in a region extending from sub-photospheric layer up to the chromosphere. In a partially ionized plasma the magnetic induction is subjected to both the ambipolar diffusion and the Hall effect in addition to the usual resistive dissipation. These nonlinear effects create sharp magnetic structures which then submit themselves to various relaxation mechanisms. A first principle derivation of these effects in a three-fluid system along with an exact static solution for the magnetic induction is deduced.

(V. Krishan, S. M. Chitre & R. T. Gangadhara)*

Coronal rotation from X-ray bright points

The aim is to identify and trace the X-ray bright points (XBPs) over the disk and use them as tracers to determine the coronal rotation. This investigation will help to clarify and understand several issues: (i) whether the corona rotates differentially, (ii) whether the rotation depends on the sizes of the XBPs, and (iii) whether there is a dependence on phases of the solar magnetic cycle. The daily full-disk soft X-ray images observed with (i) X-Ray Telescope (XRT) onboard Hinode during January, March, and April 2007, and (ii) Soft X-ray Telescope (SXT) onboard

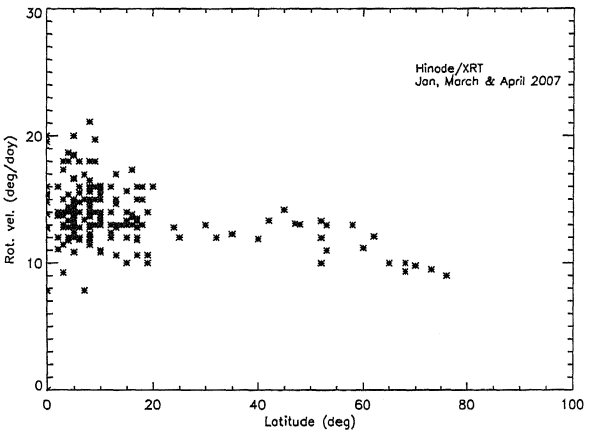


Figure 1.4: Coronal sidereal angular rotation velocity as a function of latitude to demonstrate that the corona rotates differentially. The rotation velocity has been measured with the help of XBPs as tracers from Hinode/XRT full-disk images of January, March, and April 2007.

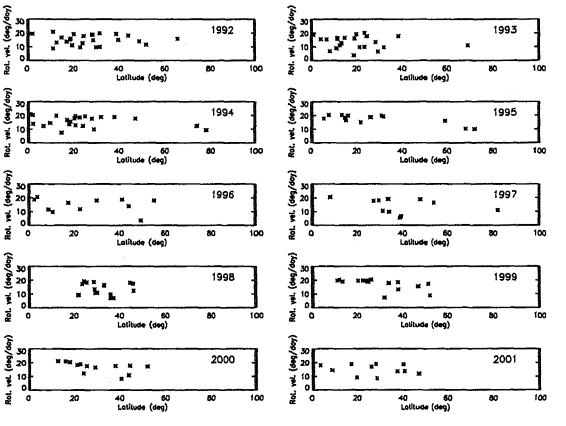


Figure 1.5: Variation in coronal rotation velocity as a function of the phases of the solar magnetic cycle. The sidereal angular rotation velocities have been derived from the XBPs in Yohkoh/SXT images for time interval from 1992 to 2001.

the Yohkoh from 1992 to 2001, have been analysed using SSW in IDL. The tracer method is used to trace the passage of XBPs over the solar disk with the help of overlaying grids and derived the sidereal angular rotation velocity and the coordinates (latitude and longitude) of the XBPs. The positions of a large number of XBPs, both in Hinode/XRT and Yohkoh/SXT images, have been determined and followed over the solar disk as a function of time. The coronal sidereal angular rotation velocity is derived and compared with heliocentric latitude as a function of solar activity cycle. In addition, the sizes of all the XBPs are measured and related to the coronal rotation. The important results derived from these investigations are: (i) the solar corona rotates differentially like the photosphere and chromosphere, (ii)

the sidereal angular rotation velocity is independent of the sizes of the XBPs, (iii) the sidereal angular rotation velocity does not depend on phases of the solar magnetic cycle, and (iv) the differential rotation of the corona is present throughout the solar magnetic cycle as seen in Figs 1.4 and 1.5.

(R. Kariyappa)

Cooler and hotter X-ray bright points from Hinode/XRT observations

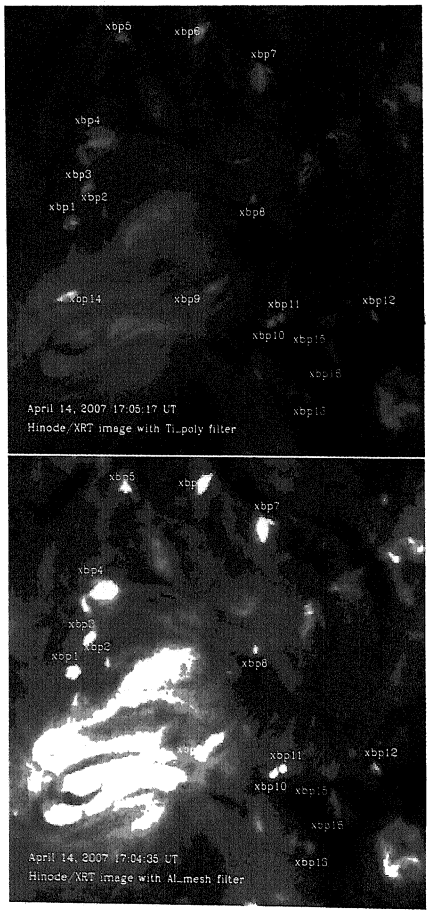


Figure 1.6: Sample of X-ray images obtained on April 14, 2007 in Ti_poly *(top)* and Al_mesh *(bottom)* filters with Hinode/XRT. The analysed XBPs are marked.

A 7-hour (17:00 UT - 24:00 UT) time sequence of soft X-ray images observed almost simultaneously in two filters (Ti_poly and Al_mesh) on April 14, 2007 with X-Ray Telescope (XRT) on-board the Hinode mission are used to determine the temperature of X-ray bright points (XBPs). A sample of 14 XBPs and 2 background coronal regions have been identified and selected on both the images for detailed

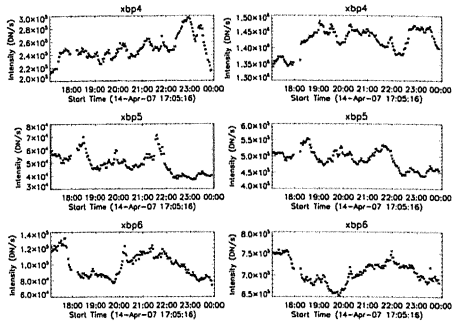


Figure 1.7: Time series of XBPs (xbp4, xbp5 & xbp6) observed in Ti_poly *(left panel)* and Al_mesh *(right panel)* filters.

analysis. The temperature of XBPs is determined by filter ratio method. It is found that the XBPs show temperature fluctuations and the average temperature ranges from 1.2 MK to 2.2 MK which may correspond to different X-ray fluxes. These results suggest the existence of cooler and hotter XBPs and the heating rate of XBPs is highly variable on short timescales as in Figs 1.6 – 1.8.

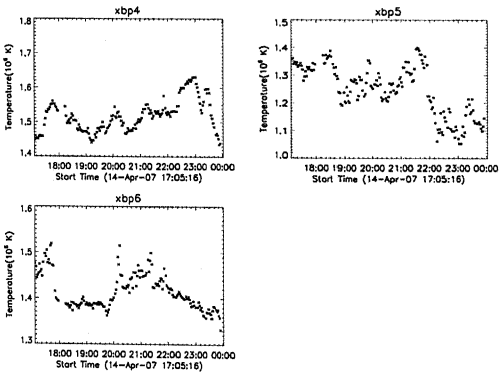


Figure 1.8: Temperature variations in XBPs (xbp4, xbp5 & xbp6).

(R. Kariyappa, E. E. DeLuca, L. Golub*, S. Saar*, S. Farid*, B. A. Varghese & T. Aditya*)*

Signatures of Alfvén waves in the polar coronal holes as seen by EIS/Hinode

Using spectral observations performed over a solar polar coronal hole region with the EIS spectrometer on Hinode, one can study the variation in the line width of a spectral line and can also calculate the electron density of the corona as a function of height. The authors used the density sensitive line pairs of Fe XII 186.88 Å & 195.119 Å and Fe XIII 203.82 Å &

202.04 Å. For the polar region, the linewidth of the spectral lines show that the nonthermal line-of-sight velocity increases from 26 km s^{-1} at 10″ above the limb to 42 km s^{-1} about 150″ (*i.e.*, ~110,000 km) above the limb. The electron density shows a decrease from 3.3×10^9 cm^{-3} to 1.9×10^8 cm^{-3} over the same distance. These results imply that the nonthermal velocity is inversely proportional to the quadratic root of the electron density, in excellent agreement with what is predicted for undamped radially propagating linear Alfvén waves. Thus this result provides signatures of Alfvén waves in the polar coronal hole regions, which could be important for the acceleration of the solar wind (see Fig. 1.9). This work has been published in Astronomy and Astrophysics letters (A&A, 501, L15, 2009).

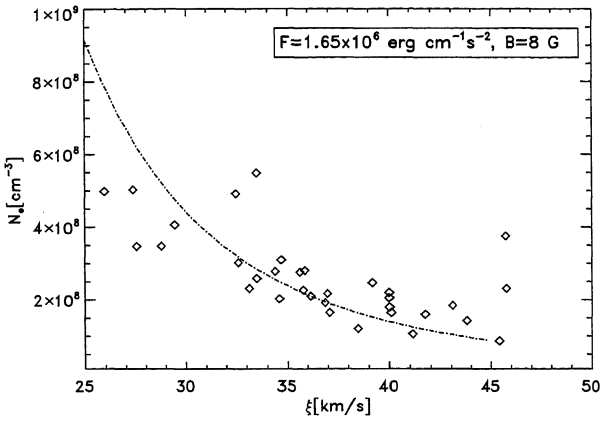


Figure 1.9: Variation in electron density with nonthermal velocity for a polar coronal hole. The squared boxes represents the observed values and the solid line represents the theoretical relation for fixed magnetic field strength.

(D. Banerjee, D. Pérez-Suárez, J. G. Doyle,*)*

Detection of slow waves in the sun

Propagating radiance oscillations have been detected in the corona, firstly in polar plumes using SOHO/UV CS, and then with SOHO/EIT. Several authors have identified the observed radiance oscillations as compressive longitudinal disturbances. From time distance maps, one can measure the travel time of the propagating oscillations and, hence, the propagation speeds of the waves that produce the oscillations. The authors have detected the presence of long period oscillations with periods of 10 to 30 min in polar coronal holes which can be interpreted in terms of magneto-acoustic slow waves. From the time distance maps one can find evidence for propagating disturbances with velocities from 75 to 125 km s^{-1}. The measured propagation speeds are subsonic, indicating that they are slow magneto-acoustic in nature. These waves can be important for the acceleration of the fast solar wind (see Fig. 1.10). This work has been published in Astronomy and Astrophysics letters (A&A 499, L29, 2009).

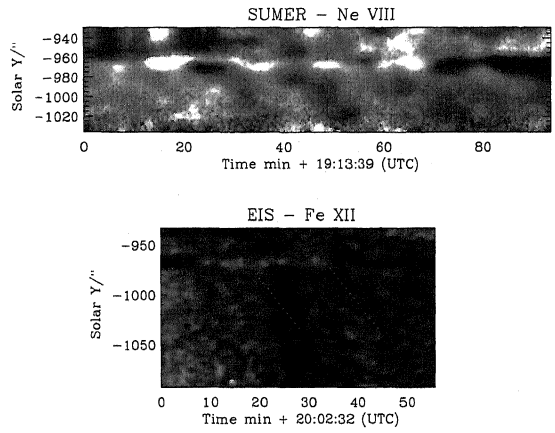


Figure 1.10: Enhanced maps of radiance variation along the slit (Solar Y direction) with time. for Ne VIII as recorded by SUMER on SOHO (top panel) and Fe XII 195 Å as recorded by EIS on HINODE (bottom panel) on 8^{th} April 2007. The vertical white dashed line on the SUMER enhanced radiance map depicts the starting point of the EIS time series showed in the bottom panel. The slanted dotted green lines correspond to disturbances propagating in the solar polar regions with a speed of 75 km s^{-1} and a period of about 15 minutes as determined from the SUMER data.

(D. Banerjee, L. Teriaca,, G. R. Gupta, S. Imada,*, G. Stenborg,*, S. K. Solanki*)*

Wave propagation and energy transport in the magnetic network of the Sun

The heating of the chromospheric network is one of the major unresolved problem in solar physics. These networks are concentrations of vertically oriented intense magnetic fields. Magnetic field plays a very important role in the generation and propagation of waves that can provide acoustic flux to the chromosphere. The propagation of waves and accompanying transport of energy in magnetic structures which are representatives of small scale magnetic flux concentrations in the magnetic network on the Sun is investigated.

Waves are generated in flux concentrations of different plasma beta on the axis at the base. The excitation of wave is inspired from the observations of dynamics of G-band bright points. The motion at the base generates magneto-acoustic waves within the flux sheet and acoustic waves into the ambient

medium. It is found that the nature of the modes excited depends upon the value of beta in the region where the driving motion occurs. For large beta, the fast wave is predominantly acoustic in nature and it undergoes mode transmission to a slow wave as it enters a region with low beta. On the other hand, in the case of a low beta excitation, the fast and slow waves are already decoupled from the beginning. The field aligned upwardly directed acoustic (Fig. 1.11a) and Poynting (Fig. 1.11b) fluxes for a low beta excitation are shown on a representative field line. With the help of such a plot it is easy to separate the energy fluxes that are carried by the slow and fast modes.

Estimation of the energy fluxes show that the Poynting fluxes are considerably lower than the acoustic fluxes. The excitation in a low beta plasma generates more acoustic fluxes than in a high beta plasma. The acoustic energy flux produced by the transverse excitation movement can temporarily reach at certain locations fluxes required to balance the chromospheric radiative losses. But our results show that the spatial averages of these energy losses cannot be balanced by the acoustic energy flux generated in our model. One solution is to use multiple short duration pulses which could also explain the observed quasi-steady heating in Ca II network grains.

(G. Vigeesh, S. S. Hasan & O. Steiner)*

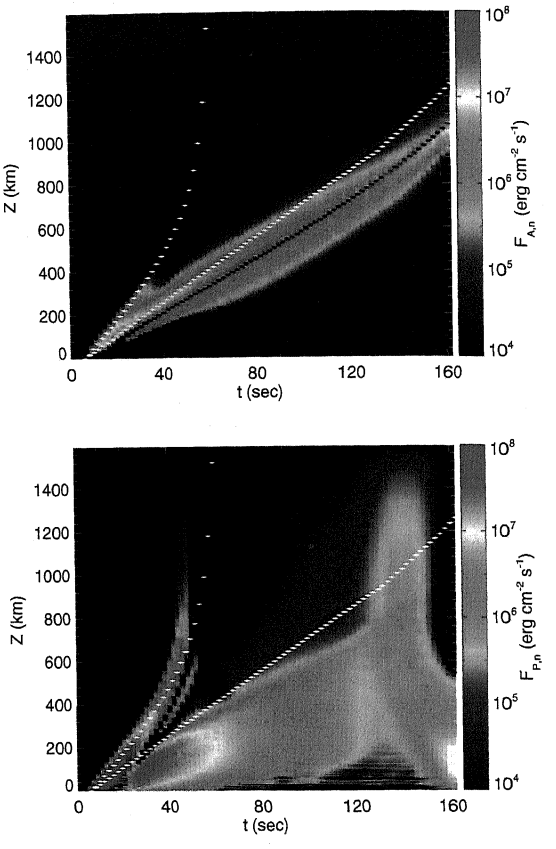


Figure 1.11: The field aligned (upward directed) components of (a) acoustic wave energy flux (top panel) and (b) Poynting flux or wave energy in the magnetic modes (bottom panel) as a function of time slightly left of the axis at a location enclosing 50% of the magnetic flux in tube. The dotted curves show the space time position of a hypothetical wavefront that travels with the Alfvén speed (steeper slope) and sound speed along this field line.

Coronal hole studies

The authors have continued their study on coronal holes using data from the Coronal Diagnostic Spectrometer (CDS) onboard SOHO. Intensity, Doppler velocity and line widths have been obtained from several emission lines in the CDS wavelength range (308 – 381 Å & 513 – 633 Å). The peak ionization temperature of these lines varies from 0.083 MK to 1.10 MK and hence represents different heights in the solar atmosphere from the upper chromosphere and transition region to the low corona. Differences between the quiet Sun region and coronal hole on the one hand, and the polar hole and the equatorial extension on the other, have been studied.

A comparison of relative Doppler velocities and spectral linewidths in a coronal hole and the nearby quiet Sun has also been made using the five strong emission lines, namely, OIII 599 Å, OV 630 Å, NeVI 562.8 Å, HeII 304(2) Å, and MgIX 368 Å. Relative velocities in the coronal hole are generally blue-shifted with respect to the quiet Sun, and the magnitude of the blue-shifts increases with height. It has been found that the polar coronal hole has larger relative velocities than the equatorial extension in the inner corona. Several localized velocity contours have been found mainly on network brightenings and in the vicinity of the coronal hole boundary. Velocity contours on the network may represent network outflows while the latter could be due to localized jets probably arising out of the magnetic reconnection at the boundary. All spectral lines have larger widths in the coronal hole than in the quiet Sun. In OV 630 Å, an extended low-linewidth region is seen in the coronal hole-quiet Sun boundary which may indicate fresh mass transfer across the boundary. Also, the polar coronal hole has larger linewidths than those in the equatorial extension. Together with larger relative velocities, this suggests that the solar wind emanating from polar hole regions is faster than that from equatorial hole regions.

(K. P. Raju)

Chromospheric network

The Calcium K images from Kodaikanal Solar Observatory have been used to study the solar activity. The images are dominated by the chromospheric network and plages. While the network is a manifestation of the solar convective scale - supergranulation, plages represent the newly emerged active regions on the solar surface. Programmes have been developed to obtain the network and plage indices from the daily images as functions of solar latitude and time. The data covers a period of about 100 years and hence contains information on several solar cycles. The study is expected to give insights on solar activity, solar differential rotation and the interaction between the magnetic field and convection.

(K. P. Raju & J. Singh)

Study of the solar interior through gravity modes

Helioseismology, the study of oscillations of the surface of the Sun - has proved to be a powerful tool to improve our knowledge on the Sun and its interior. It enables us to locate the position of the base of the convective zone, to measure the content of Helium, the sound speed profile and the neutrinos. All these results were obtained with acoustic (p) modes. However, today, the solar interior is still ill-constrained, such as the rotation in the core, the density or the magnetic field deep in the core. Gravity (g) modes are the best probes to understand the solar interior and to improve our knowledge on the solar core dynamics as they propagate in the radiative zone. The detection of the fingerprints of these g modes (García et al., 2007, Science, 316, 1591) opened a new era. Although individual rotational splittings for g modes have not yet been calculated, the effect of these modes have to be understood, and also low-degree high-frequency p modes, on the inversion of the solar rotation rate below 0.2 solar radius. The same methodology as in Mathur et al. (2008, A&A, 484, 517) has been used: by adding g modes and low-degree high-frequency p modes to artificial inversion data sets. This work done by S. Mathur, A. Eff-Darwich* and R. A. García* led to the conclusion that a few modes measured with a good accuracy can bring information on the trend of the rotation rate in the solar core whereas low-degree high-frequency p modes improve the region between 0.1 and 0.2 solar radius.

Besides, the CEA Saclay has developed a prototype of a new generation of instruments to look for g modes (GOLF-New Generation, PI: S. Turck-Chièze*, which is the successor of GOLF, Global Oscillations at Low Frequency, aboard the satellite SOHO). The main improvement of this prototype is the measurement at different heights in the photosphere to try to remove the solar noise, which prevents from detecting the g modes. It was installed in June 2008 at the Teide Observatory (Canary Islands) where it operated during the whole of summer 2008. The data were analysed at the CEA in Saclay leading to the observation of the known p modes at different heights.

(S. Mathur, A. Eff-Darwich & R. A. García*)*

Are the magnetic fields of the polar faculae generated by a local dynamo ?

Polar faculae (henceforth PF) are bright smallscale structures, a few seconds of arc in diameter, that can be seen near the north and south poles of the Sun in white light images as well as in the images of chromospheric lines like the Ca II K line. The numbers of PF and the area they occupy in the polar zones above heliographic latitudes $\pm$ 50 – 60° vary cyclically and 180 out of phase with the sunspot cycle. High resolution observations show that PF posses kilo-Gauss fields. It is estimated that the magnetic flux per PF is of the order of $\approx 10^{19}$ Mx and PF have life times in the range of 7–10 hours . The magnetic fields of the PF constitute the magnetic fields at the poles.

Although enough observations on the evolutionary patterns of the PF and the magnetic fields associated with them are available, the question as to where and how the magnetic fields of PF are created in the solar interior have remained open.

Studies in recent years, have shown that by matching the surface rotation rates of magnetic features (sunspots, small magnetic elements) with the rotation rate profiles in the interior derived from helioseismology data (plot of rotation rates vs depth in the interior), it is possible to estimate the depths of the plasma layers in the convection zone where the foot points of the flux tubes of these magnetic features are anchored. Using this procedure the authors have projected the rotation rates of PF measured by Varsik, Wilson and Li (Solar Phys. Vol 184 , p 223 ; 1999) in the latitude belt 55 – 80 deg on the rotation profiles derived from the helioseismic (Global Oscillations Network Group) data and read off depths corresponding to the intercepts at 55, 60, 65, 70, 75 and 80 deg latitudes. These depths lie

in the range of $r/R_\odot = 0.96 - 0.98$ (where r is the radial distance and ($R_\odot$) the Sun's radius) and represent the depths at which the foot points of the flux tubes of the PF are anchored. These are precisely the depths where there are shear flows of the solar plasma which could amplify magnetic fields locally through a dynamo action. From this, the authors infer that the magnetic fields of the PF are indeed generated by a local dynamo operating in the sub-surface shear layers at depths of $r/R_\odot = 0.96 - 0.98$.

(K. R. Sivaraman, H. M. Antia & S. M. Chitre*)*

Evidence for the return meridional flow in the convection zone from sunspot data of Kodaikanal (1906 – 1987)

In this preliminary study, we show that the velocity of meridional flow at different depths in the convection zone can be inferred by measuring the latitude drifts of spot groups by binning them into different area classes. This is based on the proven concept that the flux tubes of large spots are anchored deeper in the convection zone than those of the smaller spots and the motions of sunspots (either in longitude or latitude) reflect the motions of the plasma layers at their respective anchor depths .

The data consists of heliographic coordinates and areas of nearly 20,000 spot groups measured from the daily photographic images of the Sun from the Kodaikanal Observatory archives for the period 1906–1987. The authors have divided the spot groups into 3 umbral area classes : $< 5\mu$; $5 - 10\ \mu$, and $> 10\mu$ (μ - millionths of the hemisphere) and computed the latitude drift (in deg / day) of every spot group on all the days of observation. The authors then averaged the latitude drifts over all spot groups in each of the 3 area classes to reduce the noise and then converted the mean drifts to meridional velocities (in m s^{-1}) in the usual way. Their analysis shows that the latitude drifts of spot groups in the three area classes $0 - 5\ \mu$, $5 - 10\ \mu$ and $> 10\ \mu$ are directed equatorward over the the latitude belt $\pm$ 40 deg and the mean velocities of flow are 7 ± 4 m s^{-1}), 6 ± 3 m s^{-1}) and 5 ± 2 m s^{-1}) respectively i.e. the velocities of equatorward meridional flow decrease with the increase in area of spot groups.

The authors have obtained estimates of the anchor depths of flux tubes of spot groups belonging to the three area classes independently by matching their respective average rotation rates with the rotation rate vs depth profiles from helioseismic inversions. The mean depths for the $< 5\mu$; $5 - 10\ \mu$ area classes over the sunspot latitude belt read from the helioseismic plots are $r/R_\odot = 0.87$, 0.83 and 0.75 respectively (where r is the radial distance and $R_\odot$ the Sun's radius). They conclude that the meridional velocities determined are those of the meridional flows directed equatorward at these three depths in the convection zone.

(K. R. Sivaraman, H. Sivaraman, S. S. Gupta, & R. F. Howard*)*

Understanding the role of polar magnetic fields in the solar cycle process

The importance of the role of the magnetic flux at the poles (polar magnetic fields) is beginning to be realized with the arrival of results from more and more observations of the magnetic fields at the poles. The polar fields that carry a total magnetic flux comparable to the flux contained in all the active regions put together over one cycle, also show a cyclic variations with maxima and minima that are out of phase with those of the conventional sunspot activity (Sheeley 1964, 1991, ApJ, 140, 731; Makarov and Sivaraman 1989 Solar Phys. 123, 367). Although it is realized that the polar fields do have a role to play in the solar cycle process, the precise nature of their contribution is far from clear. The authors have a project proposal (under preparation) that envisages a detailed study of the flux in the polar fields from cycle to cycle and to relate them with the dynamical processes leading to the polar field reversals using the data on polar faculae and sunspots covering a full century (1906 – 2007).

(K. R. Sivaraman, Neil Sheeley, Nagovitsyn*, Tava stsherna*, V. I. Makarova*)*

Sunspot seismology: control experiments on surface magnetic effects

Following the author's earlier work on the sub-surface structure of sunspots using deep-focus time-distance helioseismology, a set of control experiments aimed at assessing contaminations from various near-surface causes including, wave diffraction, smearing due to phase-speed filters, and modified acoustic environment around the sunspot have been performed. Using data on a large sunspot (NOAA AR9057, diameter $\approx$ 32 Mm) observed by the Michelson Doppler Imager (MDI) onboard SOHO, the control experiments involve measuring travel times for a surface travel distance of 50 Mm over wave frequency bands of 1

mHz centered at every 0.25 mHz interval between 2.5 and 5 mHz: (1) a deep-focus geometry involving wave-paths (green colour, as shown in Fig 1.12) connecting diametrically opposite points on the cyan coloured circle (a thin annulus, in reality), with foci falling under the umbral area at about a depth of 17 Mm, and (2) surface-focus geometry for wave-paths with foci falling in the annular area bounded by the red circles outside of the sunspot, i.e. in the apparently non-magnetic or weakly magnetized region, and with the end points falling over the large circle. The green and blue portions for the circle or annulus corresponding to the end points of surface-focus wave paths separate them into those that cross the sunspot underneath it from those that do not, respectively. Perturbations in deep-focus travel times are denoted as $\delta\tau^{df}$, and those in surface focus times as $\delta\tau^{sfs}$ and $\delta\tau^{sfq}$ for wave-paths that cross (green) and that do not (blue), respectively. To check if $\delta\tau_u^{df}$,

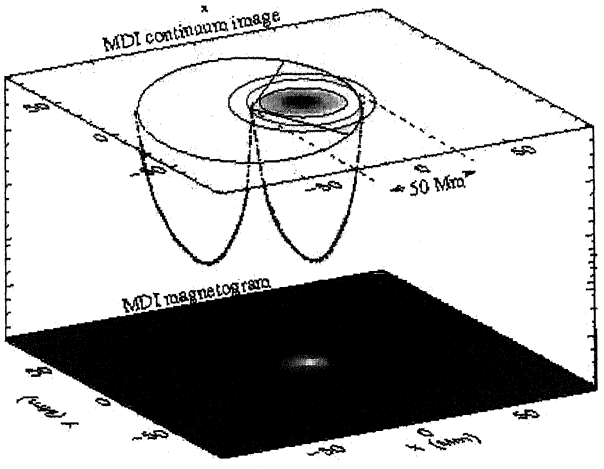


Figure 1.12: Depiction of wave-path and time-distance helioseismic measurement geometry used for the controlled experiments described in this work; please refer to the text for details.

where the subscript u denotes umbral area average, indeed come from depths around the foci we project or convolve the surface-focus travel times $\delta\tau^{sfs}$ and $\delta\tau^{sfq}$ over the deep-focus annuli (cyan colour). The resulting averages are denoted as $\delta\tau_a^{sfs}$ and $\delta\tau_a^{sfq}$. The results, plotted against the wave frequency ν in Fig 1.13, show that the deep-focus perturbations $\delta\tau_u^{df}$ are more than twice that of $\delta\tau_u^{sfq}$, and are of similar values as $\delta\tau_u^{sfs}$, which are for wave-paths that cross the spot at depth. More importantly, the differences between the surface- and deep-focus perturbations do not show any significant ν (or wavelength) dependence, and hence argue against any wave diffraction effects due to the sunspot magnetic field.

(S. P. Rajaguru)

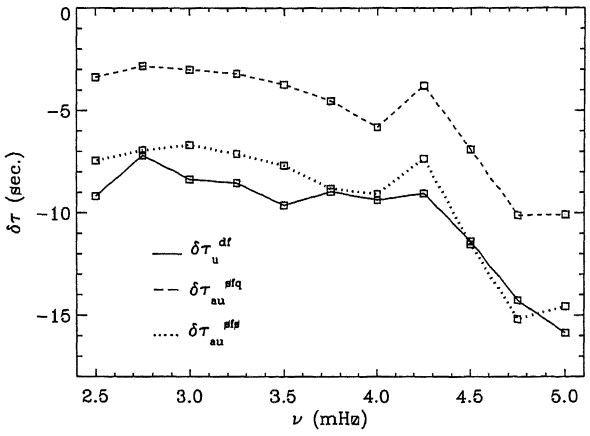


Figure 1.13: Comparison of deep-focus and projected surface-focus travel times over an annular region as shown in Fig 1.12; see text for more details.

Coronal helicity in emerging active region

Sunspots often emerge as bipolar regions on the solar surface resembling the Ω shaped flux tubes. Longcope and Welsch (2000, ApJ, 545, 1089) predicted that a current generated in the twisted emerging flux tube will enter the corona. Any initial current mismatch between the photosphere and corona results in magnetic torque which drives rotation of the magnetic footpoints. To verify this prediction the authors decompose the helicity flux into spin and braiding components. The MDI high resolution magnetograms of AR NOAA 8578 are used in this study. As soon as the active region started emerg-

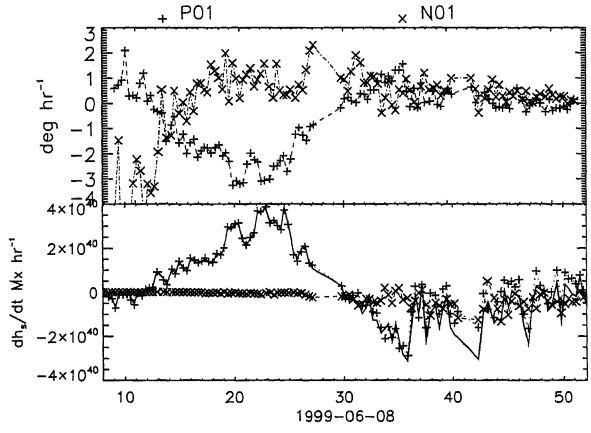


Figure 1.14: The rate of rotation of the leading and the following regions during the emergence period. Bottom: Rate of spin helicity injection as a result of rotation.

ing, the leading polarity region started rotating anticlockwise, but gradually changed its direction of rotation to clockwise as seen in Fig. 1.14. The fol-

lowing polarity, followed a mirror-image evolution of the leading polarity. This observation is consistent with the propagation of twist along one of the active region's submerged legs as a torsional Alfvén wave packet. The shape of the packet explains the variation in rotation direction of one polarity. Its propagation through the corona would then cause the other polarity to rotate in the opposite sense. This result proves the Longcope's prediction.

(B. Ravindra & D. W. Longcope,)*

Formation of chromospheric infrared emission lines of helium and hydrogen

Emission lines of Helium at (10830.3 Å), Hydrogen Paschen β (12818.1 Å), and Hydrogen Brackett γ (21655.5 Å) were observed off-limb of the Sun in the chromosphere, for the first time using the newly acquired infrared camera at the McMath-Pierce telescope facility. The observations cover every 10^o around the limb. The ratio of the blue 10829 component to the red 10830 component of the He multiplet derived by fitting the observed profiles prove that the lines are formed by the mechanism of photoionization of atoms by EUV irradiance and subsequent recombination, instead of collisional excitation by electrons from the transition region. The ratio from these observations show a closer match with that of the theoretically predicted ratio from FAL-C atmospheric model unlike the earlier spicule observations. However, comparing the FWHM for the helium and hydrogen lines in the chromospheric region, it is found that the emission mechanisms for these lines are different.

(Usha Sree Tejomoortula, Debi Prasad Choudhary*, K. E. Rangarajan, Na Deng*, Matthew J. Penn*)*

Variability of coronal background x-ray emission

X-ray irradiance in the spectral range of 1 – 8 Å obtained from the GOES satellite has been analyzed in detail. A lag of about two years of background x-ray emission with respect to the sunspot activity is a feature when the sunspot numbers are considered and such a lag is not present when the sunspot area is considered. This explains a direct relationship between active region magnetic flux and the energy radiated in X-rays and that this relationship is nearly linear. The observed delayed response of the 1 – 8 Å coronal emission index with respect to the sunspot numbers is explained in terms of the underestimations of the sunspot numbers that arise due to the same weight factor assigned to all the spot groups.

(K. B. Ramesh)

Preparations for IIA's Eclipse expedition of July 22, 2009

IIA's plans for the eclipse expedition of July 22, 2009 centered on the scientific motivation of investigating the possibility that magnetohydrodynamic waves drive the heating of the solar corona. The proposed experiments include both imaging and spectroscopy in the green and red emission lines, and are planned to be conducted at a camp to be set up in Anji, a small hilly area near Hangzhou, China. This site was carefully chosen after optimizing for both the duration of totality (5 minutes 38 seconds) and the likelihood of good weather conditions.

While the temperature of the Sun is about 5700 degrees at the photospheric level, it rises to a million degrees in the solar corona. This enormous heating effect is as yet not understood. Among the several physical processes proposed, heating driven by magnetohydrodynamic waves is one, and this phenomenon would typically leave oscillatory signatures in intensity and velocity signals observed in the solar corona. Many attempts have been made to detect these oscillations but the results are contradictory.

Imaging of the solar corona has the advantages of providing the information over a two dimensional region, but it is subject to small uncertainties arising from variations in sky transparency. On the other hand, spectroscopy provides data only over a small portion of the solar corona but with spectral purity, and the variations in the sky transparency can be taken into account. Line profiles can also yield information about the temperature and non-thermal structure of the solar corona.

Two 40 cm telescopes with effective focal length of 200 cm each, fitted with CCD cameras will be used to image the solar corona. These telescopes will image the corona in the green line (530.3 nanometres) and the red line (637.4 nanometres) respectively, at a rate of one 200 millisecond exposure every second. The 2K x 2K CCDs have a pixel size of 13.5 micron, and will thus cover the solar corona up to 1.5 solar radii where most of the emission occurs.

A 30 cm two-mirror system (coelostat) will be used to direct the sun- and coronal light to a 10 cm objective to form an image of the corona on the slit of the Littrow type spectrograph, fitted with a grat-

ing with 600 lines per mm blazed at 2 microns. Two 1K x 1K CCD cameras with pixel size of 13.0 x 13.0 microns will be used to record the spectra of the solar corona at a frequency of about 5 Hz with an exposure time of 200 ms.

Figure 1.15: The spectrograph which will be used to take the spectra in the green and red emission lines simultaneously.

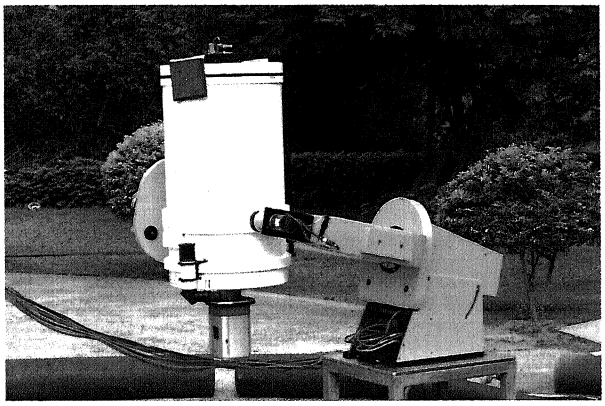


Figure 1.16: The 40-cm telescope which will be used to take the images of the solar corona at Kavalur to calibrate the exposure time.

(Jagdev Singh)

A prediction for amplitude of Solar Cycle 24

Based on an earlier analysis of Greenwich and Solar Optical Obse erving Network sunspot group data covering the period 1874 – 2006, we found that: (i) the sum of the areas of the sunspot groups in the $0° - 10°$ latitude interval of the Sun's northern hemisphere and in the time-interval of -1.35 year to +2.15 years from the time of the preceding minimum of a solar cycle n correlates well with the amplitude (maximum of the smoothed monthly sunspot number) of the cycle $n + 1$ (correlation coefficient $r = 0.947$); (ii) it was also found that the sum of the areas of the spot groups in the $0° - 10°$ latitude interval of the southern hemisphere and in the time-interval of 1.0 year to 1.75 year just after the time of the maximum of the cycle n correlates very well ($r = 0.966$) with the amplitude of cycle $n + 1$ (Javaraiah 2007, MNRAS, 377, L 34).

With further analysis of the data, it was found that the north – south asymmetries in the sums of the areas of spot groups in the $0° - 10°$ latitude interval have a strong $\approx$44 - year periodicity, and from this it can inferred that the upcoming cycle 24 will be weaker than cycle 23. The authors further found that the north – south asymmetry in the area sum of a cycle n also has a relationship with the amplitude of cycle $n + 1$, which is similar to (i) but with a higher correlation coefficient ($r = 0.968$). Using this correlation, it is possible to predict the amplitude of a cycle with a better accuracy by about 13 years in advance, and get 103 ± 10 for the amplitude of the upcoming cycle 24. Additionally, it was found that a similar relationship with an even higher correlation coefficient ($r = 0.983$), by using the sum of the area used in (ii) above and the north south asymmetries in the sums of the areas of spot groups in the $0° - 10°$ latitude interval. Using this last correlation, it is possible to predict the amplitude of a cycle by about 9 years in advance with a high accuracy, and get 87 ± 7 for the amplitude of cycle 24, which is about 28% less than the amplitude of cycle 23. The authors results also indicate that cycle 25 will be stronger than cycle 24. The variations in the mean meridional motions of the spot groups during odd and even numbered cycles suggest that the solar meridional flows may transport magnetic flux across the solar equator and are potentially responsible for all the above relationships as seen in Fig 1.17. (Appeared in Solar Physics, 2008, 252, 419).

(J. Javaraiah)

Long-term variations in the solar meridional flow

Studying temporal variations in the solar differential rotation and meridional flows is important for understanding the underlying mechanism of the solar variability. Besides Doppler velocity measurements, observations of the longitudinal and latitudinal drifts of magnetic tracers, particularly sunspots, are traditionally used as proxies of solar fluid motions to

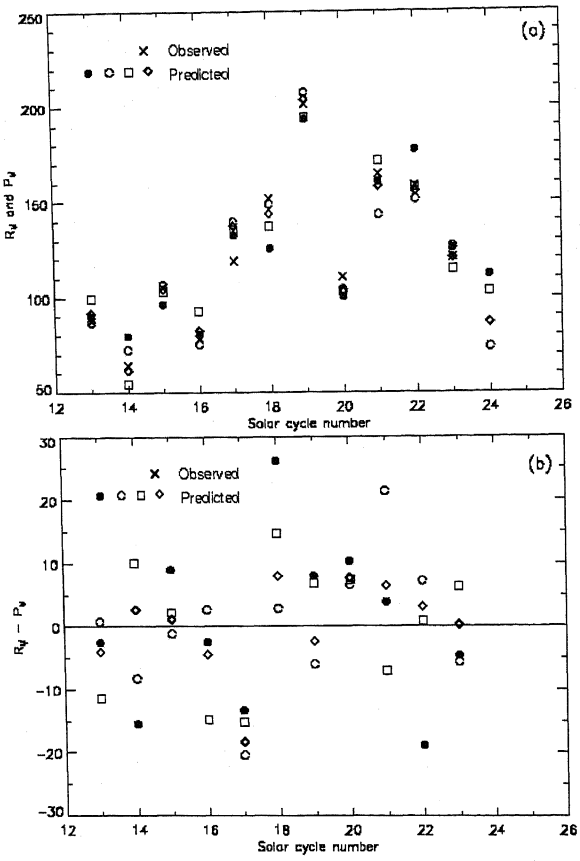


Figure 1.17: Against the Solar cycle number are plotted the observed and simulated amplitudes (panel a) and the differences between the observed and simulated amplitudes (panel b).

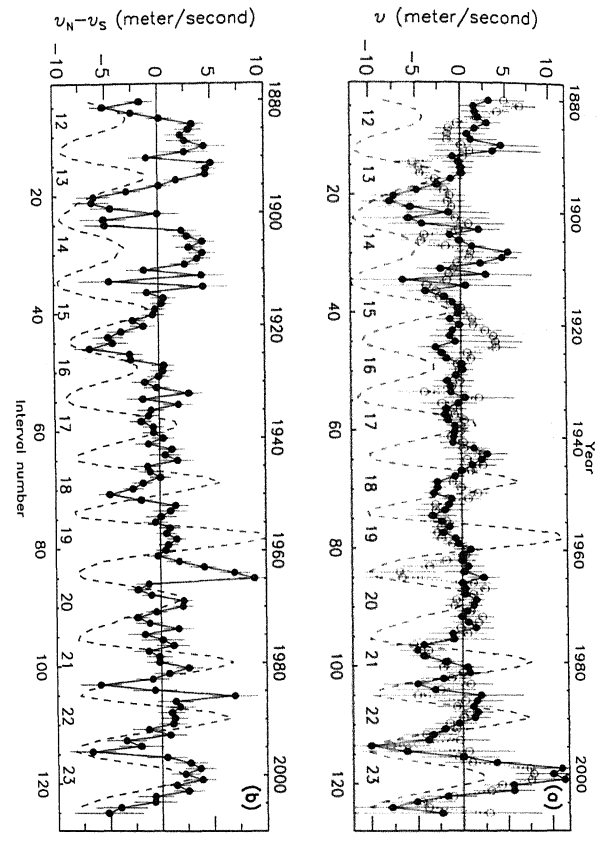


Figure 1.18: Variations in mean meridional motion of the sunspot groups during the period 1879 - 2008 for the northern hemisphere (solid curve) and the southern hemisphere (dotted curve) and the corresponding north-south difference ($v_N - v_S$, lower panel), determined by binning the data into 3-year moving time intervals, shifted by one here. A positive value (in upper panel) represents the north-bound motion. In both panels the dashed curve represents the variation (smoothed by taking 3-year running average) in sunspot activity during 1879 - 2007. The Waldmeier cycle number is specified near each maximum epoch.

study the solar rotation and meridional flows. Using sunspot group data from Greenwich and SOON during the period 1879 – 2008, the author found that the mean meridional motion of the spot groups varies considerably on a timescale of about 10 – 20 years (See Fig. 1.18). During the current cycle 23, which is anomalous in the sense that the cycles pair 22, 23 violated the Gnevyshev and Ohl rule, the mean meridional speed of the spot groups is substantially higher than that it was during the last 10 – 11 cycles. The authors also found a roughly 18-year periodicity in the mean meridional motion of the spot groups in the northern hemisphere and a roughly 25-year periodicity in the north-south asymmetry of the mean meridional motion.

(J. Javaraiah)

Quasi 9-day periodicity in the solar differential rotation

Using the daily Mt. Wilson Doppler velocity data during 1986 – 1994, the author has studied the short-term variations of the order of a few days to a month, in the solar differential rotation, which can be represented in the form: $\omega(\phi) = \bar{A} + \bar{B}(5sin^2\phi - 1) + \bar{C}(21sin^4\phi - 14sin^2\phi + 1)$, using a set of Gegenbauer polynomials (Snodgrass H.B., Solar Phys., 94, 13, 1994). The parameter $\bar{A}$ represents the equatorial (mean) rotation rate, $\bar{B}$ and $\bar{C}$ are the measures of the latitude gradient of the solar rotation rate with $\bar{B}$ representing mainly low latitudes and $\bar{C}$ representing largely higher latitudes. There is no cross-talk among $\bar{A}$, $\bar{B}$ and $\bar{C}$. He found that a $\approx$ 9-day periodicity is dominant in the variation of $\bar{C}$ at the maximum of solar cycle 22. A similar periodicity is found to be significant in the variation of $\bar{B}$ during the descending phase of the cycle 22 with $\geq$ 99.9% confidence level. The $\approx$ 9-day periodicity in the

variation of the differential rotation approximately matches with the known quasi 10-day periodicity in the total solar irradiance (TSI) variability. Hence, the author speculates that there exists a relationship between the differential rotation and TSI variability. Also, he suggests that the 9 – 10 day periodicities of the differential rotation and TSI may have a relationship with the production and the emergence rates of the largescale solar magnetic flux. The detailed analysis is under progress.

(J. Javaraiah)

Revisit to the classic Wilson effect

The classic Wilson Effect is a geometric phenomenon observed in single isolated sunspots. As the spot approaches the limb, the width of the penumbra on the disk-center side decreases more rapidly than the width on the limb-ward side. This effect is ascribed to a saucer-shaped depression of the spot and to increased transparency of the sunspot atmosphere owing to its lower temperature and gas pressure. However most studies, especially those that involved observations of large numbers of sunspots, reported very significant percentage of cases with no Wilson effect or with an inverse Wilson effect. These results have generally been ignored as being attributable to non-uniformity in the shape of penumbrae or various difficulties in the actual measurement of the effect. The authors have examined the Wilson effect in 580 epochs of sunspots observed at the Kodaikanal Observatory. Only spots which are well isolated from opposite polarity spots or pores (49%) do not display the Wilson effect. Unipolar spots also show a decrement of the effect that seems to be related to age. However, bipolar spots (45%) do not display the Wilson effect, whereas spots associated with a mixed-polarity magnetic configuration (6%) show an inverse effect. We are studying the dynamic responses of spot penumbrae to their ambient magnetic configuration.

(S. P. Bagare)

Studies of molecular lines in sunspot umbral spectra

High resolution Fourier transform spectrometer spectra of sunspot umbrae were studied to search for signatures of several molecules suspected to be present in the umbral atmosphere. These identifications can serve as useful diagnostics for studying the atmospheric conditions above the umbrae. The presence of metal oxide lines due to the series LaO, ScO, and VO were confirmed. Similar studies of the boron series of diatoms confirmed the presence of BF and BS while the presence of BH was found to be questionable. The reason for doubtful presence of BH needs further investigation. The effective temperatures were estimated for the molecules identified.

(S. P. Bagare, B. Karthikeyan, P. Sriramachandran* & N. Rajamanickam*)*

New views on the physics of the solar cycle

Genesis of the near periodic 11 year sunspot (and 22 year magnetic) cycle phenomenon is one of the outstanding problems in solar physics. The present paradigm is the so called turbulent and flux transport dynamo mechanism that mimics some of the observed properties of the solar cycle and activity phenomena, even though there are serious and fundamental difficulties that are to be addressed. Keeping in mind such difficulties and following Alfven (1943, Arkiv. Math. Astr. Fys., 29A, No. 12), the following new ideas on the physics of the solar cycle and activity phenomena are proposed. In order to have the stability, the sun's interior consists of combined weak poloidal (Hiremath, K. M and Gokhale, M. H., 1995, ApJ, 448, 437) and strong toroidal (Hiremath, K. M., 2001, BASI, 29, 169) magnetic field structures that may be of primordial origin. Along the weak poloidal field structure (that isorotates with the internal plasma rotation), Alfven perturbations of long period ($\sim$ 22 years) from the deep interior, travel first to the poles in both the hemispheres and later reaches the equator. While traveling towards the surface, Alfven perturbations in turn perturb the embedded strong toroidal field structure, especially in the convective envelope, producing sunspots that travel to the surface due to buoyancy. Computation of Alfven travel times along different field lines of the poloidal field structure (Hiremath, K. M & Gokhale, M. H., 1995, ApJ, 448, 437) in the solar interior, yields almost similar periods, explaining the constancy of period of odd degree modes, obtained from the Spherical Harmonic Fourier analysis of the surface magnetic field. The observed periodicities of sunspot and magnetic activity in the range of 1 – 5 years are explained due to perturbation of the strong toroidal field structure and, variation of the long period solar cycle and activity phenomena such as the Maunder and grand minima are explained due to coupling of poloidal and toroidal MHD oscillations.

(K. M. Hiremath)

New views on the physics of the solar cycle : Forecast and backcast of the solar cycles

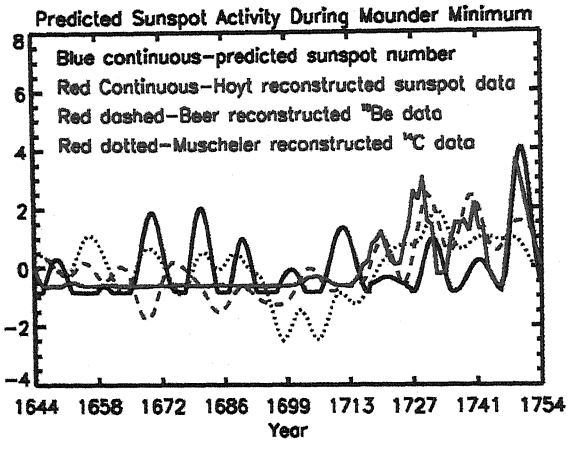


Figure 1.19: Deviation from the mean and normalized to their respective standard deviations of the predicted sunspot activity during the solar Maunder minimum period.

In the framework of axisymmetric and incompressible plasma, Chandrasekhar's (1956, ApJ, 124, 231) MHD equations for the poloidal and toroidal components of the magnetic field structure with a forcing term are perturbed. With reasonable approximations and by using two perturbed equations, a single equation is derived that is similar to a equation of forced and damped harmonic oscillator. The amplitudes, frequencies, phases and decay factors of such a harmonic oscillator are determined by fitting the equation of the sinusoidal and transient parts to the sunspot data for the years 1755 – 1996 (cycles 1 – 22). Using these physical parameters of the 22 solar cycles and by an autoregressive model, the amplitude and period of future sixteen solar cycles (23 – 38; i.e., from the years 1996 – 2175 AD) and 11 cycles before the era of regular observations of the sunspots (i.e., from the years 1644 – 1754 AD) are computed. The amplitude and period of the predicted cycle 23 is almost similar to the observed values. The present cycle 24 will have a small amplitude (110±11) during maximum year compared to the previous cycle 23. Although predicted activity (as in Fig. 1.19) during the years 1644 – 1754 is very low, similar to Maunder minimum type of sunspot activity, predictions match very well with the solar proxy (C^{14} and Be^{10}) data.

(K. M. Hiremath)

Observations of the Evershed flows in sunspots during the past 100 years

Right from discovery of the Evershed effect, observations of Evershed flow velocity of the sunspots is surveyed from literature. Aim of the present study is to examine whether magnitude of the peak Evershed flow velocity at photospheric level is dependent on the strength of the solar activity cycle or not. Analysis of the extensive survey from the literature shows that magnitude of the peak velocity of the Evershed flow of the sunspots is independent of strength of the solar activity cycle. The model (Gokhale, M. H and Hiremath, K. M., 1986, AdSpR, 6, 47G) on the genesis of the Evershed flow is revisited. Although it is premature to conclude from the analysis of the inhomogeneous data set that the modeled velocity flow is inconsistent with the peak velocity flow that is independent of strength of the solar cycle, the model of Gokhale and Hiremath (1986) is consistent with some of the high resolution observations of the sunspots' structure with strong horizontal radial outflow in the penumbra and a weak inflow in the umbra at the photospheric level. Similarly, except siphon flow model, all other models do not satisfy the observed criterion of the present study.

(K. M. Hiremath)

Average thermal structure of sunspots during their initial appearance

As the spot groups with different lifespans have distributed anchoring depths (Hiremath, K. M., A & A, 386, 674, 2002 and references therein), observations of the sunspots' dynamics, magnetic fields and thermal structures during their initial appearance on the surface, can be used for inferring these physical variables in the convective envelope. Ultimate aim of the present study is to estimate thermal structure of the convective envelope. Keeping in mind these crucial views, 160 bipolar sunspots are analysed. For different sizes and lifespans during their initial appearance on the surface and by using SOHO/MDI continuum images, average intensity of the umbra and the whole spots are measured. After computing the intensity of penumbra and umbra-penumbra intensity ratio, average temperature of umbra, penumbra and the whole spots are computed. Important findings of this preliminary study are : (i) smaller spots are brighter than larger spots, (ii) depths of penumbrae may be shallower compared to those of umbrae, (iii) brighter umbrae have brighter penum-

brae and vice versa and, (iv) umbra-penumbra ratio – a measure of thermal structure of the convective envelope – is different for different lifespans indicating different temperature structure at the sunspots' anchoring depths.

(K. M. Hiremath & B. B. Akshatha Bhat)*

Initial rotation rates of the leading and following sunspots

Positions of the leading and following bipolar sunspots are located and rotation rates are computed from the six years of SOHO/MDI magnetograms, during their initial appearance on the sun's surface. It is found that the leading spots rotate faster than the following spots. Bipolar spots with a small lifespan rotate faster than the spot groups with large lifespans. It is also found that variation of rotation rates of both the leading and following sunspots, with respect to their different lifespans are almost similar to radial variation of the internal rotation as inferred by the helioseismic studies confirming the previous study (Hiremath, K. M., 2002, A&A, 386, 674), that the sunspots which have different lifespans are anchored at different depths in the convective envelope.

(M. R. Lovely & K. M. Hiremath)*

Search for the elusive solar internal g-modes

Physics of the central part of the radiative core is poorly understood. The low degree g-modes are most sensitive to the central part of the radiative core, hence unambiguous detection of internal g-modes is essential. So far, none of the studies have succeeded in detecting the solar g-modes. One of the main reason is that they have very low amplitudes near the surface. Hence, innovative instrumentations, data analysis and theory are necessary for the detection. From an analysis of the VIRGO/SOHO hourly data, for the year 1996, of total solar irradiance (TSI), although significant peaks at 16 hour, 1 and 4 day periodicities are found from the FFT analysis, no signal near the expected 'g' mode oscillations is detected. With a view to enhance the weak g-mode signal, 'p' and 'g' modes are considered to be coupled, forced and damped harmonic oscillators and resulting amplitudes of coupled oscillations are analytically solved. With a phase difference of 90^o, the resulting solution of either 'p' or 'g' coupled modes is the same.

(K. M. Hiremath)

Low frequency radio observations of coronal magnetic fields

Magnetic field dominates the structure and dynamics of most of the solar corona. Despite its fundamental importance, only a few direct measurements of the coronal magnetic field are available, essentially due to the lack of observational facilities. Estimation of magnetic fields in the solar photosphere through Zeeman splitting of Fraunhofer lines is a well-established and reliable technique. In the absence of similar method for the upper layers in the solar atmosphere, considerable resources are spent in extrapolating the observed solar surface magnetic field distribution under the assumption that it is potential or force-free. In the radio domain, high resolution circular polarization observations at high frequencies (GHz) are used at times to measure the field strengths above active regions at heights 0.05 $R_\odot$ from the solar surface. In the height range 0.1 – 0.8 $R_\odot$ radio noise storms are one of the potential candidates since they are usually circularly polarized and are the most frequently observed solar activity at low frequencies (30 – 300 MHz). Note that linear polarization, if present at the source region in the solar corona, tends to be obliterated over any finite band of frequencies by differential Faraday rotation of the plane of polarization, between the source and observer. The noise storms orginate from the corona above sunspots with strong magnetic field. So we may expect similar fields in the coronal regions were they occur.

We have made observations of circularly polarized emission from noise storm continuum source in the solar corona at 77 & 109 MHz during the period 11 – 18 August 2006 using the East-West one-dimensional radio polarimeter at the Gauribidanur observatory. Two-dimensional imaging observations at 77 MHz during the same epoch with the radioheliograph at the observatory revealed that the radio source was associated with the sunspot region AR 10904 during Carrington Rotation 2046 and co-rotated with it. The radial distance (r) of the corresponding 77 MHz plasma level was derived from the above rotation and is 1.21 $R_\odot$. The average magnetic field value that follows from the observed circularly polarized emission at this plasma level and radial distance is 4 G. The maximum magnetic field at the corresponding distance above AR 10904 obtained using PFSS technique is about 6 G (see Fig 1.20).

(R. Ramesh, C. Kathiravan & S. M. Sonnett)*

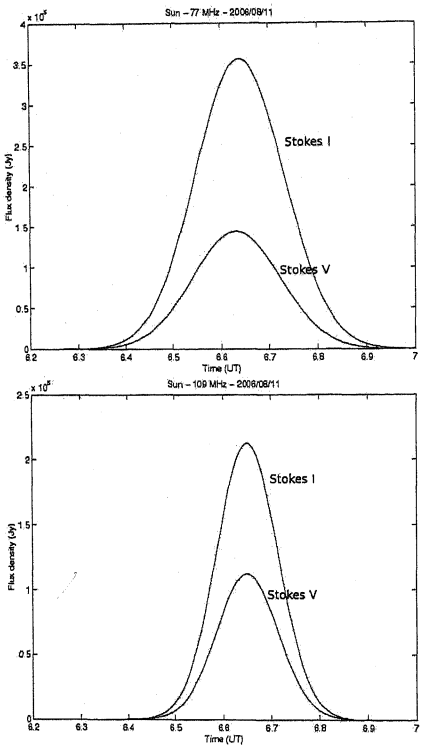


Figure 1.20: Stokes I & V observations of the radio emission from the solar corona at 77 & 109 MHz on 11 August 2006 with the Gauribidanur radio polarimeter.

Kinematics of metric type II radio bursts, and Coronal Mass Ejections (CMEs)

The kinematics of metric type II radio bursts, and Coronal mass Ejections (CMEs) were studied using data of type II bursts temporally associated with limb CMEs events. For the metric type II radio bursts dynamic spectra of 59 type II radio bursts were used to derive the speed of the shock waves, using Newkirk's density model for the solar corona. Second order polynomial fits were made to the data derived from the dynamic spectra of type II radio bursts. The speed of the shock waves causing type II radio bursts was estimated from these fits. It is found that the speeds of metric type II radio bursts are weakly correlated with the speeds of the CMEs associated with type II radio bursts. This suggests that the drivers of metric type II radio bursts may not be CMEs, but flares (see Fig. 1.21).

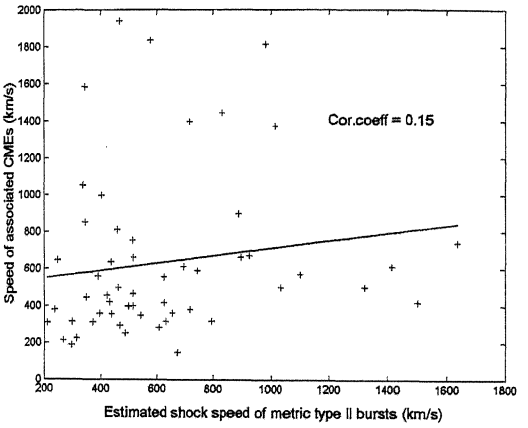


Figure 1.21: Scatter plot between the speeds of metric type II radio bursts and those of associated CMEs.

(K. R. Subramanian & E. Ebenezer)

1.2 Planetary Sciences

Polarization of extrasolar planet

Recently, the detection of linear polarization in the blue band from an extrasolar hot giant planet HD 189733b has been reported. The observed peak amplitude of polarization is a few times of 10^{-4}, more than an order of magnitude higher than all theoretical predictions. Rayleigh scattering off H_2 and He may although give rise to a high albedo and hence a planet-star flux ratio of the order of 10^{-4} in the blue band, it cannot account for the high polarization unless the planet has an unusually extended atmosphere. Therefore, it is suggested that the high polarization should be attributed to the presence of a thin cloud of sub-micron size dust grains in the upper visible atmosphere which supports the observational finding of an almost feature-less transmission spectrum between 550 and 1050 nm with no indication of the expected alkaline absorption features. It is found that the polarimetry observation allows for a small eccentricity of the orbit that is predicted from the time delay of the secondary eclipse of the planet. The estimated longitude of the ascending node is $16^o \pm 6$ which interestingly coincides with the observationally inferred location of the peak hemisphere-integrated brightness.

(Sujan Sengupta)

Modeling of the non-impact related dust morphology of comet Tempel 1

Modeling of the non-impact related dust morphology of comet Tempel 1 was completed. Four main active regions at mean latitudes $+45^o \pm 5^o$ (D), $0^o \pm 5^o$ (E), $-30^o \pm 5^o$ (A) and $-60^o \pm 5^o$ (F) are found to explain the morphology of the dust coma in the ground-based and published images obtained by the High Resolution Instrument (HRI) cameras aboard the deep-impact flyby spacecraft. From a quantitative fit of the intensity distribution in the observed and the simulated images, we find that the fraction of the productivity of the active vents to the total dust emission of the comet is 27 %. The fitted velocity parameter v_0 of grains from the sources 'D', 'E' and 'F' is found to be significantly low at 70 m s^{-1} in comparison with the dust velocities for other comets which are in the range 200 – 600 m s^{-1}. The physics of subsurface sublimation and diffusion is very tricky. However, intuitively one can argue that the velocity of cometary material released by mini and micro explosions will be lower than that of individual cometary dust grains entrained in the expanding gas after sublimation from the surface. The lower ejection velocities thus support the process of dust ejection in Tempel 1 by distributed and frequent micro explosions. The dust grains from the source 'A' are found to be ejected at even slower velocities at $v_0 = 24$ m s^{-1}. Hence we propose that sublimation of CO_2 may be responsible for the source 'A' while sublimation of H_2O drives the grains from the other sources. The velocity of emission of CO_2 is lower in comparison to such velocity for H_2O molecules by factors $\sqrt{18/44}$ due to the difference in the molecular mass and $\sqrt{110/200}$ due to difference in the sublimation temperature.

(R. Vasundhara)

Modeling of the Deep Impact plume from comet Tempel 1

On July 4, 2005, NASA's deep-impact probe successfully collided with the nucleus of the Jupiter-family comet 9P/Tempel 1. The effects of the impact were observed during the spacecraft flyby and from several ground-based telescopes and space-based facilities. The optical-imaging observations acquired at the 2.5 m Isaac Newton Telescope (INT) on La Palma, Canary Islands (Spain) obtained on July 1 – 7, 2005 were modelled. The evolution of the plume during 4 – 7 July was analyzed. The position angle of the ejecta cone is found to be $230^o \pm 10^o$. It is found, that a two component dust ejecta consisting of a high-angle plume A and a low-angle ejecta plume B, explained the dust morphology. The material in plume B may be associated with the low-angle ejecta fan (curtain) related to the excavation flow during the initial stages. High velocity of the grains and the presence of amorphous carbon in this plume agrees with the scenario by Harker et al. (2007, Icarus 190, 432) that the material contained in this plume came from the surface layer. The mass excavated in the high-angle plume (A) originating from deeper regions of the comet is around 60% of the total mass excavated following the deep impact. Images of the plume on July 5 – 7 show a diffused tail structure in the S – E direction originating from regions close to the nucleus (feature C). It is postulated that the grains that produce this feature are the fragmented grains breaking loose from the slow moving heavier grains of population A, in the base of the plume. It was possible to model this feature with the assumption that the fragmented population has the initial velocity of the parent grain but moves under the ac-

tion of the radiation pressure force corresponding to their size.

(S. C. Lowry, R. Vasundhara, A. Fitzsimmons*, G. Jones* & A. Coates*)*

Uniqueness of the Sun as a star : Clues for absence of super Earths

The sun appears to be a peculiar and unique stellar object in terms of its high mass, metallicity, solar activity and as a single star in its stellar neighborhood. Considering the most reliable part of the near equatorial internal radial rotation profile, helisoeismic inferences yield the two rotational shears, viz., near base of the convection zone and near the surface. Although analytical (Hiremath, K. M., 2001, BASI, 29, 169) and 3D MHD numerical (Brun *et. al.*, ApJ, 614, 1073, 2004 and references therein) studies satisfactorily reproduced isorotational contours from base of the convection zone to rotational shear layer near the surface, none of the studies so far have reproduced the negative rotational gradient from $0.935R_\odot$ to $1R_\odot$. That compels one to conclude that such a rotational shear layer near the surface might be peculiar and unique to the sun as a star. From the dynamical stability criterion (Mestel 1999), it is concluded that such a slow rotational shear layer might have been acquired by the sun during its past evolutionary history during its planetary formation. Interestingly the total mass of such a layer from $0.935R_\odot$ to $1R_\odot$ near the sun's surface has $\sim 0.001\ M_\odot$ that is $\sim$ one Jupiter mass. Thus instead of one Jupiter mass that must have been distributed in formation of the terrestrial planets (total mass of all the terrestrial planets including moon and the asteroid belt is $\sim 0.006M_J$, where M_J is mass of the Jupiter), it might have accreted on to the sun. This interesting physical reasoning suggests that if the sun is not unique in terms its high mass, then the stars with planetary systems in the universe must show an inverse relationship between the planetary mass (that orbit very close to the stars) and their host stars' mass. In order to test this hypothesis, 50 G type stars that have exoplanets are considered and the analysis yields an inverse relationship $(M_p/M_J) = (0.6609 \pm 0.0060) - (0.1469 \pm 0.0035)(M_{star}/M_\odot)$, (where, M_p is the planetary mass, M_{star} and $M_\odot$ are the masses of the host stars and the sun respectively) between the planetary and host star's mass confirming the hypothesis.

(K. M. Hiremath)

Peculiar sun, flares and planets

From the dynamical point of view and present level of detection of exoplanets, it is found that the sun is peculiar and unique in having a moderate rotational shear layer near the surface that might have accreted onto the sun during the epoch of the planet formation. It is also discovered (Hiremath and Suryanarayana, A&A, 411, L497, 2003) from the Kodaikanal Observatory white light pictures and the Hα data set that the bipolar sunspots while emerging from the interior reconnect around $(0.935R_\odot)$ the rotational shear layer and eventually majority of the high energy flares occur. Is this flaring mechanism unique to the sun or very common to the host stars that have planets in the universe ? In order to test this hypothesis, we surveyed many host stars that have planets. As the flares emit right from the gamma rays to the radio waves, in the Hα and CaII emission lines, previous observations in these windows are searched from the literature. Preliminary results indicate that most of the stars that have flare occurrences have also the planets. This study is in progress.

(K. M. Hiremath, V. H. Doddamani, V. Gangadhara* & B. A. Kagali*)*

Magnetic field structure of Mercury

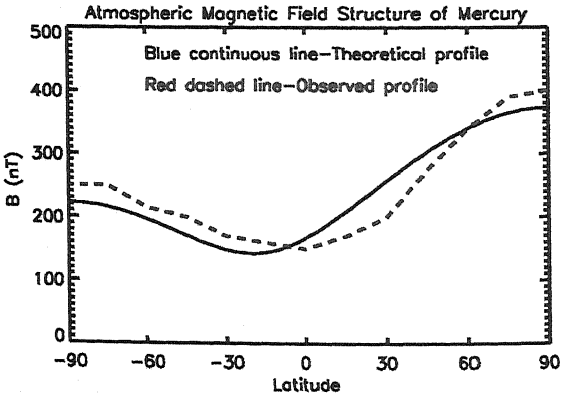


Figure 1.22: Atmospheric magnetic field structure of Mercury. Red dashed line is the observed profile (read from Fig. 3 of Anderson et al. Science, 321, 82, 2008) and blue continuous line is the theoretical profile.

Recently, the planet Mercury – unexplored territory in our solar system – has been of much interest to the scientific community, due to the recent flyby of the spacecraft Messenger, very close to the surface of the planet, and discovered its intrinsic stationary

dipole like magnetic field structure with a intensity of $\sim$ 300 nanotesla confirming the previous observation of the Mariner 10 spacecraft. As the planet rotates very slowly ($\sim$ 59 days), it is very unlikely that such a stationary largescale magnetic field structure is generated and maintained by the geodynamo like processes. Alternatively, the internal magnetic field structure of Mercury is modelled as a solution of the magnetic diffusion equation in an incompressible medium of constant diffusivity. By the estimates of magnetic diffusivity of the previous studies from the constraints of the thermal and dynamical history of the planet's core and, by imposing appropriate boundary conditions at the core-mantle boundary for the first two diffusion terms, the present study puts the constraint on Mercury's core radius ($\sim$ 2000 km) and also satisfies the observed profile of the magnetic field structure (as in Fig. 1.22) in the atmosphere as inferred by Messenger spacecraft. From the estimated magnetic diffusivity and the core radius, it is is also possible to estimate the two diffusion eigen modes with their diffusion time-scales of the $\sim$ 8.6 and $\sim$ 3.7 billion yrs respectively suggesting that the planet is inherited its present day field structure from the solar nebula.

(K. M. Hiremath)

Structure and kinematics of the Indian lithosphere

Broadband recordings of seismic data were continued at Kodaikanal, Leh and Hanle, as well as of Global Positioning System with valuable contributions from the Observatories, scientists and B. C. Bhatt. The resulting long time series data constitute a critical requirement for better constraining the fine structures of the Indian crust and upper mantle. A particular emphasis during the year has been in attempting a continent wide synthesis of data by collaborating with scientists elsewhere, resulting in three comprehensive papers on the subject.

(V. Gaur)

1.3 Stellar and Galactic Astrophysics

Imaging and spectroscopy of star-forming clouds

Stars are born in dense, dusty and cold interstellar clouds. The lower mass young stellar objects (YSOs) generally show hydrogen emission lines in their spectra. The more massive YSOs (OB stars) produce ionised regions around them and affect the parent cloud in several ways. Often clumps of gas and dust in the remnant cloud are irradiated and blown away to produce the so-called bright-rimmed clouds or cometary globules. Imaging in broad band and narrow band (H_α, S[II]) filters has been carried out to investigate, together with radio and infrared measurements, the three dimensional morphology of the ionised regions in a few star-forming clouds including IC 1396 which shows a number of cometary globules harbouring lower mass YSOs. The YSOs were also observed spectroscopically to determine their spectral classes and H_α line emission strengths. YSOs close to the bright rims are found to have large and variable line emission.

(Rumpa Choudhury & H. C. Bhatt)

Abundances of neutron-capture elements in CEMP stars : A parametric model based study

A number of Carbon-Enhanced Metal-Poor (CEMP) stars are known to exhibit enhancement of both $r-$ and $s-$process elements. An understanding of their relative contributions would provide insight into the production mechanisms, nucleosynthetic sites and origin of the heavy elements observed in the stars. The authors have investigated ways to delineate the observed abundances into their respective $r-$ and $s-$process contributions using appropriate model functions in the framework of a parametric model.

(Aruna Goswami, P. Subramania Athiray & K. Drisya*)*

High-resolution spectroscopy of a selected sample of Barium and CH stars

A sample of Barium and CH stars were selected from Lu, P. K., (1991, AJ, 101, 2229) and Bartkevicius, A., (1996, BaltA, 5, 217) for a detailed comprehensive analysis of their elemental abundances. Spectra of about 48 objects have been obtained so far at a spectral resolution of 28,000 during 2007 – 2009, using the Echelle spectrometer attached to VBT at VBO, Kavalur. Stellar parameters: effective temperature, surface gravity and metallicities are estimated from LTE calculations using model atmospheres. A detailed analysis of the spectra is underway that is likely to give insight into the evolutionary nature of these objects.

(Aruna Goswami, S. S. Kartha & G. Selvakumar)

A super Li-rich star with very low 12C/13C

Li excess in K giants is one of the most puzzling stellar astrophysical problems to which, in the last two decades, a great deal of research has been done. The high values of Li in the super Li-rich K giants are thought to be due to the stellar nucleosynthesis and some kind of extra mixing. Interestingly, all the six super Li-rich K giants discovered so far occupy the very narrow region in the HR diagram known as the RGB luminosoity bump. Exact theory for the sudden show-up of high Li on the RGB bump is not yet known.

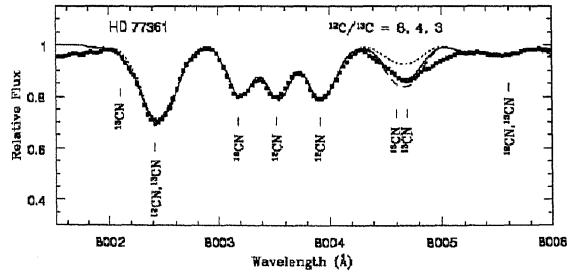


Figure 1.23: Comparison of synthetic and observed spectra obtained from the 2.3m VBT telescope equipped with the Echelle spectrograph.

To unravel the mystery of the high Li, a comprehensive survey programme of low mass K giants from the beginning of the 1st dredge-up to the tip of the RGB phase was undertaken. A total of 1800 stars with accurate distance information was chosen from the Hipparcos catalogue and subjected to low resolution spectroscopic analysis using HCT and VBO telescopes. Survey programme is almost nearing its completion and the results suggest that the Li-rich K giants are rare, and they are about 1% of the nearby disk population. The survey increased the total number of Li-rich stars in the literature by three-fold. High resolution studies of these stars with VBO and

McDonald Observatories are underway. During the analysis, it was found that one of the candidate K giants not only has a very high Li (10 times more than the ISM value) but at the same time has a very low 12C/13C 4 (as in Fig. 1.23). Results of very high Li abundance and the anomalously very low values of 12C/13C ratios are quite puzzling given the low luminosity of HD 77361 and its location at the RGB bump region. This finding may further challenge the theoretical understanding of stellar structure and mixing mechanism during the RGB phase.

(Bharat Yerra & B. Eswar Reddy)

Neon abundances in hydrogen deficient stars

The hydrogen deficient sub-class, the extreme helium (EHe) stars, overlap the hotter R Coronae Borealis (RCB) stars in effective temperature. Based on the luminosity and the effective temperature, an evolutionary link is suggested between EHes and RCBs. Photospheric abundances of these two sub-classes were compared to test this link. It emerged that EHes evolving to RCBs can only be answered by the knowledge of neon abundances in RCBs. The LTE neon abundances of RCBs have been estimated and compared with that of EHes to test this evolutionary link. However, the neon abundances suggest departures from LTE and hence, is being explored in detail for non-LTE effects.

(Gajendra Pandey, David Lambert & N. Kameswara Rao)*

Winds in hydrogen deficient stars

High resolution spectra of the five known hydrogen-deficient carbon (HdC) stars in the vicinity of the 10830 Å line of neutral helium, is presented. In R Coronae Borealis (RCB) stars, the He I line is known to be strong and broad, often with a P Cygni profile, and must be formed in the powerful winds of those stars. RCB stars have similar chemical abundances as HdC stars and also share greatly enhanced ^{18}O abundances with them, indicating a common origin for these two classes of stars, which has been suggested to be white dwarf mergers. A narrow He I absorption line may be present in the hotter HdC stars, but no line is seen in the cooler stars, and no evidence for a wind is found in any of them. The presence of wind lines in the RCB stars is strongly correlated with dust formation episodes, so the absence of wind lines in the HdC stars, which do not make dust, is as expected.

(T. R. Geballe, N. K. Rao & G. C. Clayton*)*

Dust in R Coronae Borealis stars – Study from Spitzer observations

R Coronae Borealis (RCB) stars provide a unique circumstellar environment that is hydrogen-deficient, helium-rich and carbon-rich in which dust condensation occurs. The hydrogen-poor, carbon-rich and metal-poor (in some cases) character of the gas may facilitate the formation of dust species, which are not seen in the interstellar medium or in envelopes of normal stars. Here, a library of Spitzer/IRS spectra of a complete sample of 18 RCB stars is presented and a preliminary analysis of the dust features present in the infrared spectra. This inventory of Spitzer spectra will provide important clues to the composition and dust formation process in these dusty and fascinating stars. The goal of the authors is to complement the existing sample of RCB Spitzer/IRS spectra by (a) observing warm RCBs across the composition range; (b) completing observing of the few minority RCBs; (c) sampling the coolest RCBs.

(N. Kameswara Rao, Anibal Garcia-Hernandez & David L. Lambert*)*

R Coronae Borealis at 2007 – 2009 minimum

High resolution spectra from the 2.7 m telescope of the McDonald observatory along with high resolution spectra obtained with the 2.3 m Vainu Bappu Telescope at Kavalur and 2 m Himalayan Chandra Telescope at Hanle, are being utilized to study this long protracted minimum of R CrB. The spectra reveal dust formation, by the presence of cool gas of T 1040 to 800 K prior to the onset of the minimum (drop in visual light). This is a remarkable observation, and for the first time shows, the long held belief, that dust is made in the atmosphere of the star and that the ejected clouds of dust are the cause of the occurrence of the large light drops. This is still an on-going work.

(N. Kameswara Rao & David L. Lambert)*

Mass loss from R Coronae Borealis stars

Among the hydrogen-deficient post-AGB stars are the R Coronae Borealis (RCB) stars, a small group

of carbon-rich supergiants. About 50 RCB stars are known in the Galaxy and the Magellanic Clouds. Their defining characteristics are hydrogen deficiency and unusual variability; RCB stars undergo massive decline of up to 8 mag due to the formation of carbon dust at irregular intervals. The mechanism of dust formation around RCB stars is not well understood but the dust is thought to form in or near the atmosphere of the stars. New observations of mass loss around the RCB stars is reported. The infrared and visible shells around several RCB stars using Spitzer Space Telescope (SST)/MIPS, VLTI (Very Large Telescope Interferometer/MIDI and HST/ACS have been mapped. Evidence for variable winds seen as P-Cygni or asymmetric blue-shifted profiles in the He I 10830 line in twelve RCB stars obtained with UKIRT (United Kingdom Infrared Telescope) is also presented. The dust shells and winds of the RCB stars are being modelled to determine their mass-loss rates, and to better understand their evolutionary status. This work was supported by Spitzer Space Telescope contract 1287678 issued by Caltech/JPL.

(G. C. Clayton, K. D. Gordon*, O. Chesneau*, B. Sugerman*, T. R. Geballe*, N. K. Rao, H. Neilson*)*

GALEX observations of diffuse UV radiation at high spatial resolution from the Sandage nebulosity

The authors, observed a region of nebulosity, first identified as starlight scattered by interstellar dust, by Sandage using the Galaxy Evolution Explorer (GALEX) ultraviolet imaging telescope. Apart from the airglow and zodiacal emission, the authors found a diffuse UV background, between 500 – 800 photons $cm^{-2}sr^{-1}s^{-1}$ $Å^{-1}$ (hereafter 'photon units') in both the GALEX far-ultraviolet (FUV) (1350–1750 Å) and NUV (1750–2850 Å) bands. Of this emission, up to 250 photon units is due to H2 fluorescent emission in the FUV band. The remainder is consistent with scattering from interstellar dust with forward scattering grains of albedo about 0.4. These are the highest spatial resolution observations of the diffuse UV background to date and show an intrinsic scatter beyond that expected from instrumental noise alone. Further modeling is required, to understand the nature of this scatter and its implications for the ISM.

(N. V. Sujatha, J. Murthy, A. Karnataki, R. C. Henry & L. Bianchi*)*

Study of diffuse NUV and FUV radiation using GALEX deep imaging surveys

Preliminary results have been obtained based on the analysis of 11 GALEX DIS observations from nearby regions which are at medium latitude. The errors in the FUV & NUV data of each of the observations have been estimated from its visits. Different components of diffuse UV were quantified and separated after removing the sources from each of the fields. The dependencies of these components on factors such as solar activity, Infrared 100 micron intensity, and neutral hydrogen column density specific to each of these components have been studied. In depth studies of the correlations, extraction of dust scattered component from the total radiation and the modeling of the same to extract the optical properties of dust grains in this region are underway.

(N. V. Sujatha, J. Murthy, R. Suresh, R. C. Henry*)*

Comparative study of standard stars for UVIT/Astrosat

Calibration of the filter system is a fundamental requirement for interpreting the UV imaging data. The authors have commenced a compilation of an all-sky catalog of stellar sources which would be suitable as standards for UVIT. The authors examine the optical and UV colours of standard stars spanning a range of spectral classes, particularly those with earlier UV observations and known spectral energy distributions. The calculations of instrumental magnitudes are carried out assuming unit telescope area and unit efficiency of the telescope system. The UV magnitudes and colours for the filter systems are inter-compared for Galex, Tauvex and UVIT.

The authors see that the proposed UVIT filters provide a large spread of colours and thus will be able to offer better discrimination with temperature. As the next step they plan to use a larger number of stars to see effects of spectral type and luminosity class on the colour magnitude diagram. The hope to generate a prescription of best filter combinations for certain types of observation with UVIT. This methodology can act as a planning tool for TAUVEX and UVIT missions, where multiple filters are available in each of the far UV and near UV ranges as in Figs 1.24, 1.25.

(S. G. Bhargavi & A. K. Pati)*

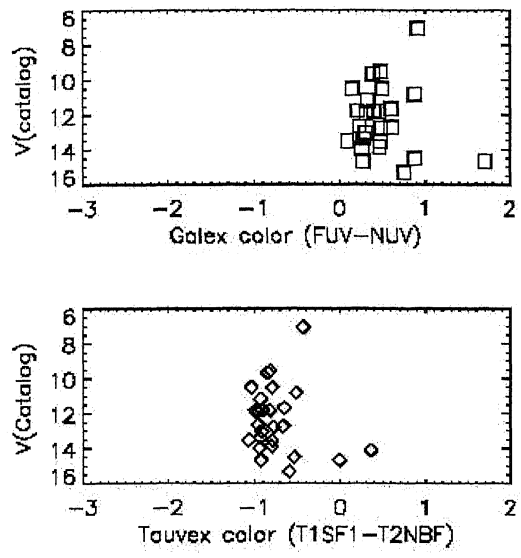


Figure 1.24:

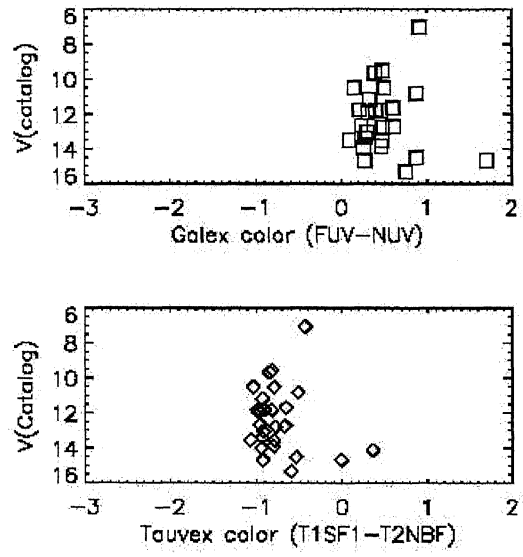


Figure 1.25: Colour magnitude diagrams of the fundamental HST standard set. The ordinate is the standard catalogue V magnitude. For each instrument the authors have chosen a (far-UV filter) minus (near UV filter) colour.

Low-resolution spectroscopy of high Galactic latitude objects: A search for CH stars

In continuation of the earlier work on CEMP stars (Goswami et al. 2007, BASI, 35, 339; Goswami et al. 2006 MNRAS, 372, 343; Goswami 2005, MNRAS, 359, 531) low resolution spectroscopic analysis has been carried out for an additional sample of about fifty objects from the Hamburg survey. The CH stars have been identified among these objects using detailed spectral classification criteria. The spectra were acquired using IIA's observing facilities at VBO, Kavalur and IAO, Hanle. Among the CEMP stars, the CH stars, that belong to the CEMP group are characterized by the strong G band of CH in their spectra. The chemical compositions of CH stars bear the signature of the nuclear processes operating in low-metallicity companion AGB stars, provided they conserve the surface characteristics of the companion AGB stars. It is therefore important to search for these objects that provide a rich source of information about the nucleosynthesis processes associated with their formation and the early Galactic chemical evolution. Estimated effective temperatures, $^{12}/^{13}$C isotopic ratios, and their location in the two colour J-H vs H-K plot support their identification with the class of CH stars.

(Aruna Goswami, K. Drisya & N. S. Shantikumar)*

The RS CVn binary UX Arietis

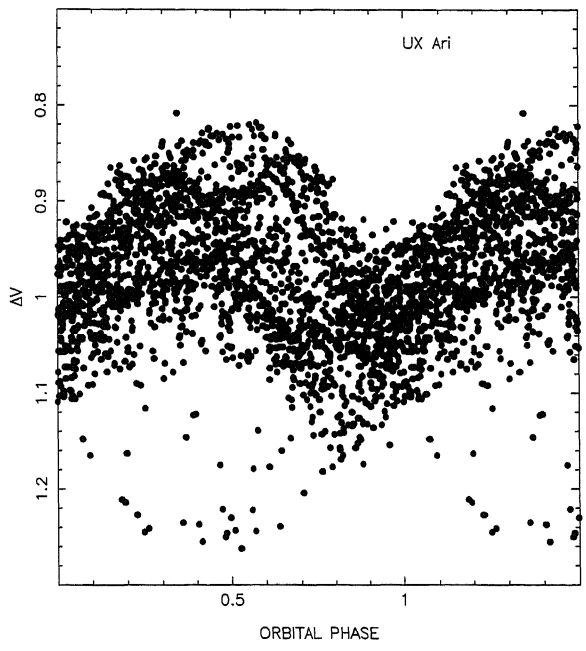


Figure 1.26: Plot of ΔV values of UX Ari obtained during 1972–2008 against the corresponding orbital phase computed using the ephemeris JD = 2450646.83 + $6^d.4372703$E.

UX Ari is one of the brightest members of RS CVn binaries, and has been observed photometrically al-

most every season since the discovery of its light variability in 1972. It is a non-eclipsing, double-lined spectroscopic binary with a K0–K1 subgiant as the primary and a G5 dwarf as the secondary in a near-circular orbit. The uncertainty in the determination of the orbital period of UX Ari is only $0^d.0000069$ and the accumulated error in orbital phase over 36 years, over which the V band observations of UX Ari span, is only $0^p.002$. It is found that the observed differential V magnitudes of UX Ari has a clear orbital modulation, implying that the spot activity in the star has a longitudinal asymmetry that is fixed in the orbital frame of reference as in Fig. 1.26. The upper envelope of the ΔV values shows a maximum around $0^p.50$. The lower boundary shows a minimum around the same phase and a maximum around $0^p.0$ where the upper envelope shows a minimum. It is remarkable that the total spread in ΔV magnitudes at $0^p.0$ observed so far is only around 0.18 mag while that at $0^p.5$ it is around 0.48 mag.

The available data clearly shows that there is enhanced spot activity in the hemisphere of the active star facing the hotter companion when compared to that which is away from it. The implication of the existence of such a longitudinal asymmetry in spot activity, which is fixed in the orbital frame of reference, is that the spots do not appear and disappear with equal probability at all longitudes on the surface of the active star in the UX Ari system. The large spread of about 0.5 mag in V magnitudes observed close to $0^p.5$ requires that the regions that produce the enhanced activity have an appreciable latitudinal extent on the surface of the active star. The rotation of a large latitudinal zone in near-perfect synchronism with the orbit would mean that differential rotation in the active star is either absent or really small. It is felt that the role of the binarity is not limited just to spin up the active star by locking its rotation with the orbital motion; the presence of a nearby companion not only causes a significant reduction in the differential rotation in the active star but also affects the physical processes that produce spots and modulates the surface distribution of spots on the active star.

(M. J. Rosario, A. V. Raveendran & M. V. Mekkaden)

The RS CVn binary DM Ursae Majoris

DM UMa belongs to the most active group of RS CVn binaries, which are presumed to undergo intense solar-type activity. DM UMa is a single-lined binary with a $7^d.5$ orbital period, and the active, visible component of the binary has been spectrally classified as K0 – 2 III – IV. In order to clearly understand the spot activity in DM UMa it has been independently monitored photometrically, at Kavalur and Mt Laguna – at the former in BV bands since the discovery of its light variability in 1979 almost continuously except for a break during 1995 – 2003, and at the latter place continuously from 1986 onwards, initially for four years in UBV bands and later in $UBVRI$ bands. From an analysis of the data collected over the years 1980 – 2008, it is found that the light curve of the star is highly variable. The long-term photometry shows no evidence of any cyclic spot activity as seen in Fig. 1.27. On one occasion the amplitude of modulation in V band was 0.30 mag, a rather high value for an active star in a binary seen at a comparatively low orbital inclination. The mean V magnitude of DM UMa during 1993 – 1994 was brighter than that over 1979 – 85 by about 0.35 mag. The monotonic increase in mean brightness, from 1984 onwards, is interpreted as due to the steady disappearance of starspots in the near-polar latitudes of

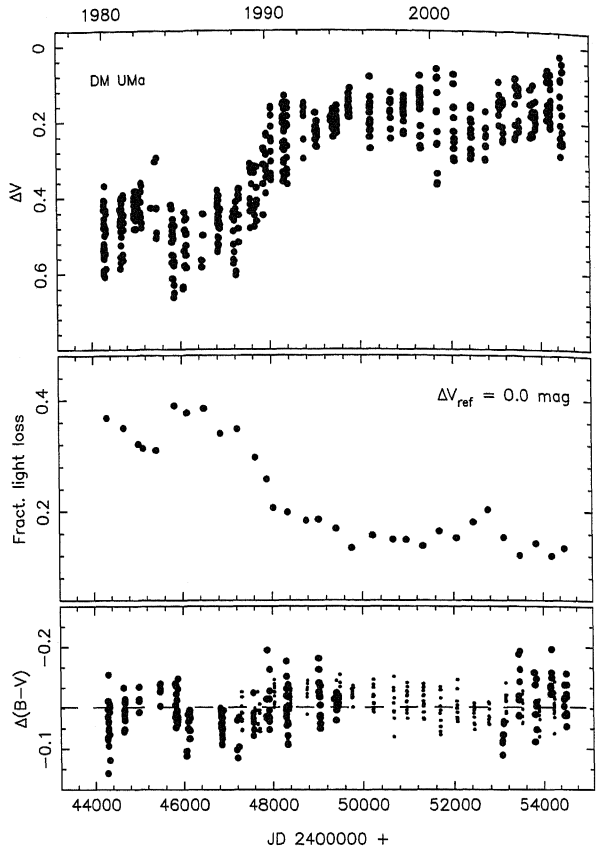


Figure 1.27: Plots of differential V magnitude of DM UMa (top panel), fractional light loss over its rotational period (middle panel) and differential $(B - V)$ colour (bottom) against the corresponding Julian days of observation.

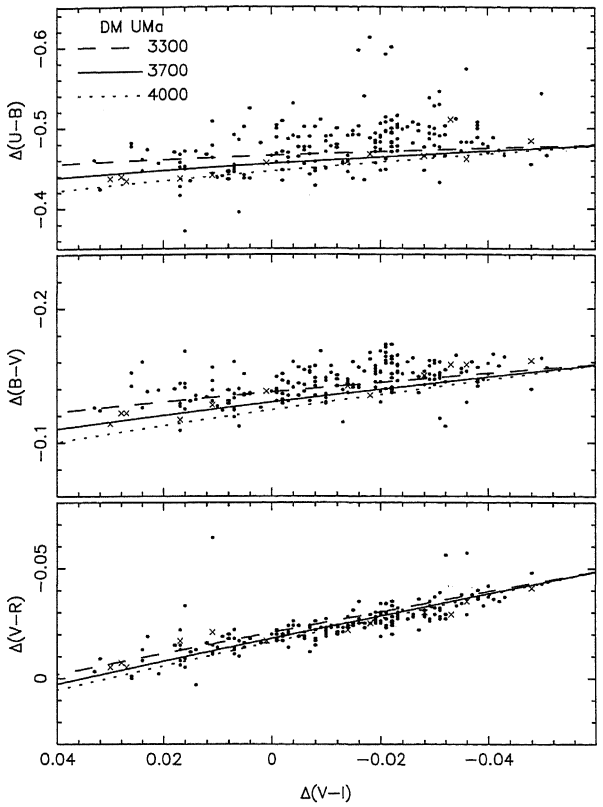


Figure 1.28: Plots of differential $(U-B)$, $(B-V)$ and $(V-R)$ colours obtained at Mt Laguna against the corresponding differential $(V-I)$ colour. The crosses indicate the observations of 2000. The lines represent the results of computations for different assumed spot temperatures, as indicated in the top panel of the figure, for an unspotted photospheric temperature of 4500 K.

the star. The V band data clearly show evidence for the presence of two distinct regions of enhanced spot activity on the visible primary, which are fixed in the orbital frame of reference, one facing the companion star and the other away from it. It appears that the nearby companion star suppresses the natural tendency of the active star for differential rotation and modifies the physical processes leading to the formation of spots, besides spinning it up by locking its rotation with the orbital motion. The variations in $(V-R)$ and $(V-I)$ colours with the V magnitudes clearly indicate that starspots about 800 K cooler than the unspotted photosphere are responsible for the rotational modulation of light in DM UMa as in Fig. 1.28. The spot-filling factors derived from TiO band strengths, which are available in the literature, are found to show the expected anti-correlation with the V magnitudes of the star. Apparently, there is excess flux in U and B bands, which increases as the star becomes fainter, partly compensating for the reduction of flux in those bands due to spot activity. The excess flux, probably, originates from plages or facular regions associated with the spot activity, and indicates that the simple two component spot model with spotted and unspotted photospheric regions is not adequate to represent the starspot activity in DM UMa.

(M. J. Rosario, P. A. Heckert, M. V. Mekkaden & A. V. Raveendran)*

Spectral analysis of AM CVn binary system

Theoretical spectra are constructed for a pair of white dwarf stars in a short period AM CVn system to explore the observational signature probing the thermal state of the mass transferring component and the evolutionary history of the binary system. Spectra were calculated for irradiated and non irradiated cool, low mass white dwarfs based on the TLUSTY stellar atmosphere code suitably modified. The spectra in the optical to near infrared wavelength band for the white dwarf pair are applied to the first confirmed eclipsing AM CVn system SDSS J0926+3624. For a model in which the emission from a nearly edge-on accretion disk is negligible in comparison to the combined photospheric emission from the two white dwarf stars, it is shown that the thermal state of the donor star can be probed at wavelengths greater than about 1.2 μm, independent of irradiation effects. In such a model, the distance of J 0926+3624 is estimated to be about 290 pc.

(Sujan Sengupta)

Polarization of Brown Dwarfs

Recent studies have detected linear polarization in L dwarfs in the optical I band. Theoretical models have been developed to explain this polarization. These models predict higher polarization at shorter wavelengths. Linear polarization measurements of 4 brown dwarfs in R and I bands are obtained by using William Herschel Telescope. As predicted by theoretical models a higher degree of polarization is found in R band when compared to polarization in I band. The observed polarization data is modeled by using single scattering approximation and the surface gravity of the L dwarfs with known projected rotational velocity is determined which is consistent with the evolutionary prediction.

(Sujan Sengupta)

Variable stars in the globular cluster NGC 6366

CCD photometry of NGC 6366 has lead to the discovery of additional variable stars. Two possible anomalous Cepheids (or Pop II Cepheids), three long period variables, one SX Phe and one eclipsing binary have been found. In addition, 10 candidate variables have been identified. The light curve of the RRab star, V1, has been decomposed into its Fourier harmonics, and the Fourier parameters were used to estimate the star's metallicity and distance; [Fe/H] = 0.87±0.14 and d = 3.2±0.1 kpc. It is possible that V1 may not be a member of the cluster but rather a more distant object. That being the case, an upper limit to the distance of the cluster of 2.8±0.1 kpc can be estimated. The PL relationship for SX Phe stars and the identified modes in the newly discovered SX Phe variable, V6, allow yet another independent determination of the distance to the cluster, d = 2.70.1 kpc. The M_V [Fe/H] relationships for RR Lyrae stars in globular clusters are reviewed and the case of V1 is discussed.

(A. Arellano Ferro, S. Giridhar, V. Rojas Lopez*, R. Figuera*, D. M. Bramich* & P. Rosenzweig*)*

Comparing observed and simulated globular clusters

The integrated spectra of globular clusters are used for developing a new method of age and metallicity estimation of the globular clusters. The estimation relies on the integrated continuum spectra. The method is similar to the method presented in Wolf et al. (2007, ApJ 655, 179 - 211). Whereas Wolf et al. use the stellar population synthesis model of Bruzual & Charlot, the author is using the N-body simulations with stellar evolution. Therefore the dynamical evolution and stellar evolution are taken into account.

Simulations of different initial particle numbers and of different galactocentric distances are used, for a comparison of observed and simulated spectra. For each simulation run, a grid of synthetic spectra, for different ages and metallicities is produced, in order to draw χ^2 plots for each observed spectrum. The simulated spectra are compared to the observed spectra from Schiavon et al. (2005, ApJS 160, 163 - 175) library.

A χ^2 fitting technique is used for the age and metallicity estimation. The age and metallicity values estimated by this technique are compared to the literature values of observed galactic globular clusters in the Harris catalogue (Harris et al. 2006, AJ 112, 1487). When considering the Schiavon et al. library, it turns out that for 30 out of 40 objects, the author's metallicity estimation is within 0.5 dex in agreement to the metallicities in Harris' catalogue.

(Andrea Borch)

Optical photometry and basic parameters of ten unstudied open clusters

BVI CCD photometry of 10 northern open clusters, NGC 6846, Tombaugh 4, Berkeley 9, Berkeley 43, Berkeley 49, Berkeley 91, Berkeley 47, Berkeley 51, Berkeley 45 and Berkeley 89 were obtained using the Himalayan Chandra Telescope. This is the first optical photometry for most of the clusters. Their fundamental parameters were estimated using the above data. 8 clusters are located in the first galactic quadrant and 2 are in the second. All the clusters have large reddening towards them (E(B−V) = 0.9 – 2.2 mag) and 8 clusters are located beyond 2 kpc. Six clusters (60% of the sample) are located well above/below the Galactic plane. Ages of 100 - 500 Myr were estimated for 6 clusters and three clusters were found to be older than or as old as 1 Gyr. This sample of clusters has increased the optical photometry of clusters beyond 2 kpc, in the second half of the first galactic quadrant from 13 to 18. NGC 6846 is found to be one of the farthest clusters in this region of the Galaxy.

(Annapurni Subramaniam, Giovanni Carraro & Kenneth A. Janes*)*

Estimates of stellar parameters in open clusters via multiwavelength photometry

This study has yielded individual estimates of reddening and distance of stars in four open clusters, the Pleiades, Praesepe, NGC 2516 and α Persei based on a scheme evolved by Maheswar et al. 2004 (MNRAS, 355, 1272). The derived distances in the range of M_V between 1.5 and 8.5 are statistically independent of luminosity. It is striking that the range in A_V is the most random and the largest in the youngest cluster α Per and the least in the oldest cluster, Praesepe. The analysis works the best for stars between A0 and M0 and is worth extending to clusters with little-known parameters. It highlights the limitations of the stellar evolutionary models. There are significant departures of the isochrones of faint stars (below $M_V \sim 8.5$); the (V−I) colours are too blue for a

given M_V. This discrepancy perhaps suggests missing sources of opacity in the calculations of models resulting in an overestimate of the V flux. Currently, the best choice seems to be the calibrated YREC isochrones generated by An et al. (2007). This method distinctly sets apart the binaries and non-members from the single stars of the cluster and is therefore a potential one in singling these out in clusters of contentious membership. The M_V vs. (B−V) colour-magnitude diagrams show that the lower mass stars fall well below the MS isochrone in the younger clusters α Per and the Pleiades. The bluer (B−V) colour has to do with the enhanced blue continuum and is absent in as old a cluster as Praesepe. This is highly likely to do with stellar activity and linked to the young age of the cluster.

(Sushma Mallik & G. Maheswar)*

Simultaneous X-ray and optical observations of the T Tauri star TW Hya

TW Hya is a nearby T Tauri star, isolated in the sky with its CS disk almost face-on and therefore has minimal obscuration and reddening effects. However, it is ridden with several controversies. It is 10 Myr old still accreting material from its CS disk onto the star; its H_α emission line is unusually broad with a distinct blue asymmetry implying stellar winds. Its rotation period has been reported at different epochs in the past to range from 1.28 to 2.8 days to even longer periods from recent observations. There is also a mystery that relates to the relative roles that accretion and coronal emission have to its source of very bright X-ray emission. To resolve these issues, a spectroscopy and photometry campaign was done in February – March, 2007. A long HETG (High Energy Transmission Grating) observation with the CHANDRA and simultaneous optical observations around the world (including the echelle spectra obtained from the 2.3 m telescope at VBO, Kavalur) were carried out to investigate the relationship between X-ray emission and optical variability and to connect these to the accretion and wind characteristics of the star. It was surprising to find that the X-ray flux over a span of 17 days did not show any periodic variations, in contrast to the optical observations. The H_α profiles were highly anomalous. There was unusual enhanced emission on the blue side which became weaker subsequently re-establishing the blue asymmetry. It was not like any seen in the past. Our observations imply it may have to do with changing wind opacity and not enhanced accretion and could arise due to changing viewing orientation of the accreting column and/or wind as the star rotates. TW Hya is in an active phase of accretion and/or wind. A sine curve placed through the X-ray data and our optical data suggests a rotation period of 2.06 days. Other recent measurements have yielded values close to 3.7 days. The big question of the rotation period of TW Hya remains!

(Sushma V. Mallik, N. S. Brickhouse & A. K. Dupree*)*

Novae

The classical nova V2491 Cygni, discovered on 2008 April 10.728 UT at a magnitude of 7.7 was spectroscopically monitored with the 2m HCT. Spectra were obtained in the wavelength range 3500 – 9200 Å. Preliminary results confirm the nova belongs to the He/N class of novae. Based on the magnitudes reported in AAVSO and IAU circulars, the nova is estimated to have a decline rate t_2 of 4.64 days, placing the nova under the fast novae category. The light curves indicate a re-brightening of the nova by about 0.5 magnitudes, beginning 10 days past maximum and lasting for about a week. The emission line widths indicate a fast moving shell with an average velocity of 5000 km s^{-1} over all phases. Quite unlike normal fast novae, V2491 Cygni showed a re-brightening by about 0.5 mag during its decline, in the transition phase. It is interesting to note that the emission line widths decreased during this phase. Also, Swift observations of this nova from 2008 April 17 to May 18 (Page et al. 2008) showed an increase in the soft X-ray flux (below 1.5 eV), with the brightness continuously increasing from 2008 April 27, in the post-optical re-brightening phase. It appears that there could be a connection with the optical re-brightening and the brightening of the X-ray source.

Recurrent novae RS Ophiuchi, T Coronae Borealis, CI Aquilae and U Scorpii were monitored at quiescence, as also the classical nova GK Persei.

(G. C. Anupama)

Supernovae SN 2007ru

The observations of the type Ic supernova SN 2007ru were continued during the nebular phase. These were combined with the observations made during the early phases and a detailed study of the evolution of the supernova over a period of 210 days made. The spectra show broad features indicating a very high expansion velocity, normally seen in hy-

pernovae. The photospheric velocity is higher than other normal Type Ic supernovae. It is lower than SN 1998bw at $\sim$ 8 days after the explosion, but is comparable at later epochs. The light curve evolution of SN 2007ru indicates a fast rise time of 8±3 days to B band maximum and a post-maximum decline more rapid than other broad-lined Type Ic supernovae. With an absolute V magnitude of -19.06, SN 2007ru is comparable in brightness with SN 1998bw and lies at the brighter end of the observed Type Ic supernovae. The ejected mass of ^{56}Ni is estimated to be $\sim 0.4 M_{\odot}$. The fast rise and decline of the light curve and the high expansion velocity suggest that SN 2007ru is an explosion with a high kinetic energy/ejecta mass ratio ($E_{\rm K}/M_{\rm ej}$). This adds to the diversity of Type Ic supernovae. Although the early phase spectra are most similar to those of the broad-lined SN 2003jd, the [OI] line profile in the nebular spectrum of SN 2007ru shows the singly-peaked profile, in contrast to the doubly-peaked profile in SN 2003jd. The singly-peaked profile, together with the high luminosity and the high expansion velocity, suggests that SN 2007ru could be an aspherical explosion viewed from the polar direction. The estimated oxygen abundance 12 + log(O/H) of $\sim$8.8 of the host galaxy indicates that SN 2007ru occurred in a region with nearly solar metallicity.

(D. K. Sahu, M. Tanaka, G. C. Anupama, U. K. Gurugubelli & K. Nomoto*)*

Supernova SN 2004A

The optical photometry and spectroscopy data of the normal type IIp supernova SN2004A, which was discovered in the galaxy NGC 6027 on 2004 January 9.84UT and observed with the 2m HCT were analysed and the temporal evolution studied. Early observations indicated the supernova was discovered at about two weeks since explosion. The distance to the host galaxy, NGC 6027 was estimated to be 20.35(± 4.5) Mpc, using the Standard Candle Method. Using this distance, the ejected nickel mass in the explosion was estimated as 0.032(± 0.02) $M_{\odot}$. The plateau luminosity, its duration (about 70 days) and the expansion velocity of the supernova ejecta at the middle of the plateau indicate an explosion energy of $4.7 \pm 2.7 \times 10^{50}$ ergs and an ejected envelope mass of 7.2(± 2.2) $M_{\odot}$. The ejected envelope mass implies a main sequence mass of 10(± 2.5)$M_{\odot}$ for the progenitor.

(U. K. Gurugubelli, D. K. Sahu, G. C. Anupama & N. K. Chakradhari)

Study of cosmic ray flux and its variation at the interplanetary space through meteorites

The study of long-term solar activity variations requires the use of radioisotopic data planetary reservoirs. At the Laboratory of Monte dei Cappuccini in Torino (IFSI Torino, INAF), for many years, radioisotopes in meteorites have been studied, because their production, which is related to galactic cosmic ray flux in the heliosphere, is anticorrelated with the heliospheric magnetic field variations. A Very sensitive gamma detection technique has been developed, in particular to measure 44Ti activity in meteorites; due to its half-life (t1 = 2 = 59:2 years), this radioisotope is an ideal index to reveal the imprint of solar activity variations on the centennial scale. Recently the spectrometer has been improved by a new multiparametric acquisition system, which allows to extract efficiently the 44Ti peak from the natural background.

(Neeharika Verma)

Planetary nebula NGC 2792

Surendiranath and collaborators have analyzed the planetary nebula NGC 2792, using multiwavelength data including new IR spectra from the Spitzer Space Observatory. They could obtain more accurate values of chemical abundances compared to other determinations done earlier. They also speculate that either the central star's radiation is quite deviant from existing model atmospheres or the PN could have a non-spherical geometry.

(R. Surendiranath, S. R. Pottasch, J. Bernard-Salas* & T. L. Roellig*)*

Transient UV events

UV transient events from specific sources such as possible collisions in extrasolar planetary systems, M dwarf flares, etc and the probability of their detection by space UV observatories, in particular by TAUVEX has been discussed. It is estimated that in one year of TAUVEX observations about 90 – 350 short scale transient events can be expected.

(C. Sivaram, M. Safonova & J. Murthy)

A full 3D model for pulsar polarization

Polarization plays a key role in understanding the geometry of pulsar radio emission mechanism and the

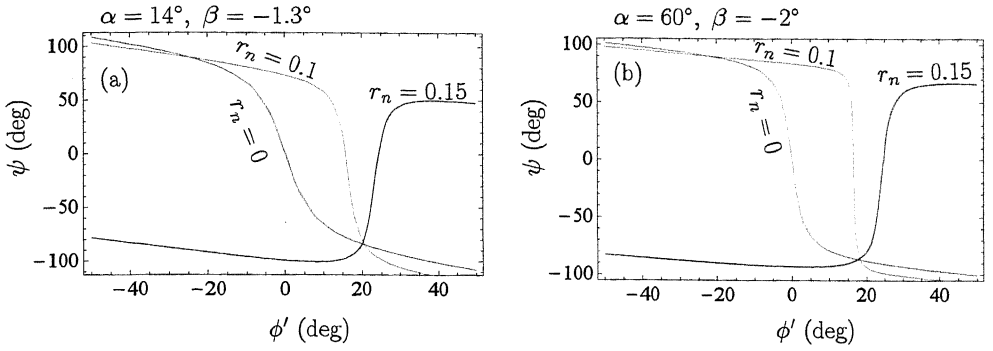


Figure 1.29: Polarization angle vs pulsar rotation phase. r_n is the emission altitude normalized with light cylinder radius, alpha and beta are the magnetic axis inclination and sight line impact parameter.

region in the rotating magnetosphere. The beamed emission from relativistic sources (plasma particles or bunches) is believed to be due to coherent curvature radio emission. Assuming uniform, as well as, modulated emissions, few typical pulse profiles were simulated. The antisymmetric circular polarization, which was often observed in pulsar profiles, is shown to be an intrinsic property of curvature radiation. It survives only when there is modulation or discrete distribution in the emitting sources. The model predicts that the rotation makes pulsar profiles to become asymmetric with respect to the meridional plane (zero phase), and the polarization angle swings reversal at some higher altitude as in the plot (Fig. 1.29).

(R. T. Gangadhara)

Absolute emission altitude of pulsars: PSR B1839+09, B1916+14 and B2111+46

The mean profiles of the following multi-component pulsars are studied: PSR B1839+09, PSR B1916+14 and PSR B2111+46. By estimating the emission height of the core components, the absolute emission altitudes of the conal components are estimated for the first time. By fitting gaussians to the emission components, the phase location of component peaks were determined. The findings indicate that the emission beams of these pulsars have a nested core-cone structure. Based on the phase location of component peaks, the aberration-retardation (A/R) phase shifts in the profiles were estimated. Due to the (A/R) phase shifts, the peak of the core component in intensity profile and the inflection point of polarization angle swings are found to be symmetrically shifted in the opposite directions with respect to the meridional plane. Hence, the phase location of meridional plane was located and the absolute emission altitude of core as well as conal components, relative to the neutron star center, were estimated using the more exact expression for phase shift.

(R. M. C. Thomas & R. T. Gangadhara)*

Building an automatic pipeline to study solar-like oscillations

Just as helioseismology allows one to understand the Sun better, asteroseismology is expected to further our understanding of all the other types of stars. Several space missions have already been observing the stars: the Canadian satellite MOST, CoRoT (Convection, Rotation and planetary Transits, which is a European mission) and Kepler (a NASA mission launched on March 7 2009). A few solar-like oscillating stars (among which HD181906, HD181420 and HD175726) have been observed by CoRoT leading to the measurement of the surface rotation period, the large spacing of the p modes, and their maximum amplitude per radial mode. However, the identification of modes is still difficult as the signal-to-noise ratio can be low. But to study the several hundreds of solar-like oscillating stars that will be observed during the Kepler survey phase, an analysis devoted to one star is impossible if one wants to have as much information as can be possible in a small period of time. Thus, the authors have developed a pipeline to analyse the acoustic oscillations as part of the several pipelines of the asteroFLAG team. This pipeline was applied to the CoRoT targets as well as many simulated data from asteroFLAG and the Aarhus group (Denmark).

(S. Mathur, R. A. García, C. Régulo*, J. Ballot* & D. Salabert*)*

Calculation of spectrum in the region of 1 – 125 keV photon energy

The theoretical spectrum in the region of 1 – 125 keV, using time-independent transfer equation in plane parallel geometry, is calculated. The solution of the radiative transfer equation is developed using discrete space theory in a homogeneous medium. The spectrum is calculated for different optical depths of medium.

It is assumed that free-free emission, absorption and emission due to electron gas is operating in the medium. The three terms n, n^2 and $\left(\frac{\partial n}{\partial x_k}\right)$ where n is photon phase density and $x_k = \left(\frac{h\nu}{kT_e}\right)$ in Kompaneets equation and those due to free-free emission are utilized to calculate the change in the photon phase density in a hot electron gas. Two types of incident radiations are considered (1) isotropic radiation with the modified black-body radiation and (2) anisotropic radiation which is angle dependent. The emergent radiation at $\tau = 0$ and reflected radiation $\tau = \tau_{max}$ are calculated by using the diffuse radiation from the medium. The emergent and reflected radiation contain the free-free emission and emission from the hot electron gas.

The initial spectrum is angle dependent, the Kompaneets equation gives a spectrum which is angle independent after many Compton scatterings.

(A. Peraiah, M. Srinivasa Rao & B. A. Varghese)*

Spectral line formation in the presence of Compton broadening by electron scattering

Radiative transfer equation in (a) plane parallel (PP) (b) spherical symmetry (SS) is solved in an electron-scattering expanding atmosphere, for obtaining the line profiles. The effects on line profiles due to (1) large optical depths (2) electron densities 10^{13}cm^{-3} and 10^{15}cm^{-3} (3) frequencies 10^{14} Hz and 10^{15} Hz (4) temperature 10^4 K and 10^5 K (5) thickness of the atmosphere $\approx 10^{12}$ cm and 10^{13} cm and (6) expanding velocities of the atmosphere is considered 10 to 20 mean thermal units (mtu) is studied. Various combinations of the above cases are used to compute the emergent line profiles observed at infinity.

The expansion of the gases produces P-Cygni type profiles and high optical depth changes the profile from absorption to emission.

(A. Peraiah & M. Srinivasa Rao)*

1.4 Extragalactic Astrophysics and Cosmology

Optical identification of XMM sources in CFHTLS

Very high quality deep optical observations were available in recent years in the Canada-France Hawaii Telescope Legacy Survey (CFHTLS). A systematic survey for quasars in 10 square degrees of the CFHTLS is being carried out with the AAOmega, in multiobject spectroscopy mode at the 4 m AAT telescope in Australia, observations of which were done spanning 6 nights (3 nights in September 2006 and 3 nights in September 2007). Part of this region has been observed in the X-ray region with XMM, UV-region with GALEX, and in the IR-region with Spitzer & WIRCAM. Quasar candidates were selected using optical and IR colour-colour diagrams and detection in X-rays. This work is being aimed at initially constructing a grid of confirmed quasars and then correlating field galaxies found in CFHTLS images, with the absorbers towards those grids of quasars. Analysis of 3 square degrees was completed during the period 2008 – 2009. A portion of this analysis reporting new optical identifications of 489 sources has been submitted for publication to MNRAS. Of these 489 X-ray sources, 267 are found to be broad-lined AGN spanning redshifts between 0.15 and 3.87 and 74 are found to be stars. In addition, 32 and 116 X-ray sources are found to be respectively absorption and emission line galaxies at z < 0.76.

(C. S. Stalin, P. Petitjean, R. Srianand*, A. J. Fox*, F. Coppalani* & A. Schwope*)*

AGN and starbursts

Powerful starburst and AGN activity have been predicted to co-exist for a short span of time during the lifetimes of the most massive galaxies by various models of galaxy formation and evolution. However, such events are rarely observed in spite of their recurrence and high luminosity. Key constraints to galaxy evolutionary models and insights into the interplay between starburst and AGN activities can be obtained by finding such systems having coeval starburst and AGN activity, understanding their nature and constraining their number density. In their ongoing work on CFHTLS fields, the authors have discovered an obscured AGN with both starburst and AGN activity at z = 3.869. See Fig. 1.30. Details of this work involving multiwavelength observations (optical, radio, IR, sub-mm) can be found in A&A, 2008, 492, 81.

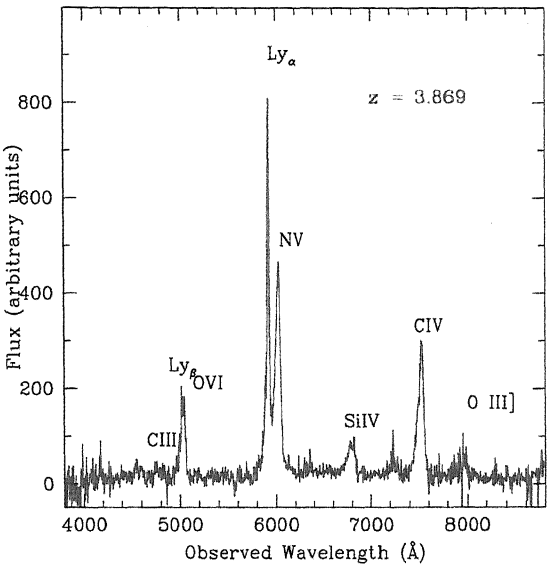


Figure 1.30: AAO omega spectrum of the z = 3.869 quasar. The prominent emission lines are marked.

(M. Polletta, A. Omont*, S. Breta*, J. Bergeron*, C. S. Stalin et al.)*

Simultaneous multiband monitoring of S5 0716+714

BL Lac objects are a group of radio loud AGN showing extreme variability in their flux at all wavelengths, high degree of linear polarization and strong gamma ray emission. The flux variability shown by these objects span over a wide range of timescales ranging from minutes to hours to months. Since the time of BL Lac research, a correlation between spectral slope and source brightness has been searched for. Some sources are found to show a spectral hardening over their flux brightening, while some other sources are found to show a reverse (i.e, spectral softening over brightening) trend. All these conflicting reports available in literature are based on quasi-simultaneous flux monitoring observations. As BL Lac objects are known to vary in timescales as short as minutes, these spectral variations of BL Lacs available in the literature (all of which are based on quasi-simultaneous multi-band monitoring) have relatively less utility than those obtained by simultaneous multi-band observations. To address this issue, new simultaneous multi-band observations over 30 nights were acquired on S50716 + 714 using the

MITSuME 3 band ($g'R_cI_c$) simultaneous imager on the 50 cm telescope at the Okayama Astrophysical Observatory, Japan during March – May 2008. In total, 4888 data frames of the BL Lac object S5 0716 + 714 were recorded which were simultaneous in g'/R_c and I_c filters. It was found from these observations that the flux variations in the different bands in S5 0716 + 714 were not achromatic, and the object was found to become bluer when brighter both within a night and between nights. A clear periodic variation of 3.3 hr was found on 1 April 2008 and a hint for another possible periodic variability of 4 hr was found on 31 March 2008 as in Fig. 1.31. Further details of this work can be found in MNRAS (2009, in press).

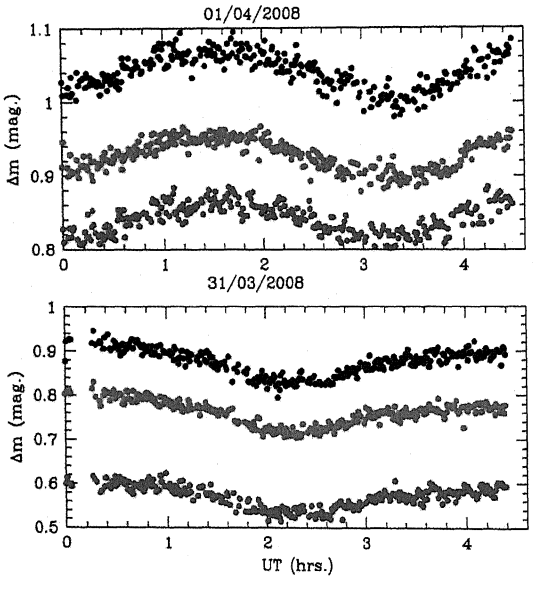


Figure 1.31: Differential light curves of S5 0716+714 in g'-band(black), R_c-band(green) and I_c-band(red). They are shifted differently on each night for clarity.

(C. S. Stalin, K. S. Kawabata, M. Uemura*, M.Yoshida*, N. Kawai*, K. Yanagisawa*, Y. Shimizu, D. Kuroda*, S. Nagayama* & H. Toda*)*

Location of the bar with respect to the disk of the Large Magellanic Cloud

The bar of the Large Magellanic Cloud (LMC) is one of the prominent, but controversial feature regarding its location with respect to the disk of the LMC. In order to study the relative location of the bar with respect to the disk, the high resolution map of the structure across the LMC is presented. The reddening corrected mean magnitudes (I_0) of red clump (RC) stars from the OGLE III catalogue is used to map the relative variation in distance (vertical structure) or variation in RC population across the LMC. The bar does not appear as an identifiable vertical feature in the map, as there is no difference in I_0 values between the bar and the disk regions. It is concluded that the LMC bar is very much part of the disk, located in the plane of the disk and it is not a separate component within 0.02 mag. Warps or variation in RC population with increase in radial distance are identified.

(Smitha Subramanian & Annapurni Subramaniam)

Nuclei of radio-powerful active galaxies on the parsec-scale

Galaxies that are in an active phase powered by their central accreting supermassive black holes, are often known to produce relativistic bipolar jets of plasma from their nuclei with enormous kinetic power, sufficient to propel the jets outside the confines of the host galaxy and into the intergalactic medium. Ordered magnetic fields around the black holes are thought to be instrumental in launching and collimating the jets, although the exact mechanisms remain untested empirically. These radio-powerful active galaxies exhibit a broad dichotomy in the morphology of their jets that roughly follows a dichotomy in total radio power (known in the literature as the Fanaroff-Riley divide). Both types of jets are relativistic at launch, but the low-powered 'type I' galaxies show decelerating, flaring jets with no clear termination points.

Taking further our previous detections of polarisation in the nuclei of Fanaroff-Riley type I galaxies on the parsec scale, which implied the unambiguous presence of ordered magnetic fields similar to the well-known results for the more relativistically beamed (and therefore "amplified") active nuclei, we used Very Long Baseline Interferometric Polarimetry to measure the Faraday rotation measure of these nuclei at multiple frequencies. We used a global interferometric array at 5, 8 and 15 GHz, that included all ten telescopes of the Very Long Baseline Array (USA) and the 100-metre Efflesberg telescope.

In one of the three galaxies, viz., 3C78 (NGC 1218), polarisation was detected at all three frequencies, yielding unambiguous Faraday rotation measure estimates. Interestingly, this galaxy shows evidence for a Faraday Rotation measure gradient transverse to the jet, very similar to results for a handful of beamed active nuclei in the literature. The transverse rotation measure gradient has been interpreted

as a signature of helical magnetic fields in them. Based on the measured gradient for 3C78, its large Faraday rotation and small depolarization, it was argued that the Faraday screen is formed by a layer surrounding the jet and carrying a helical magnetic field (Fig. 1.32).

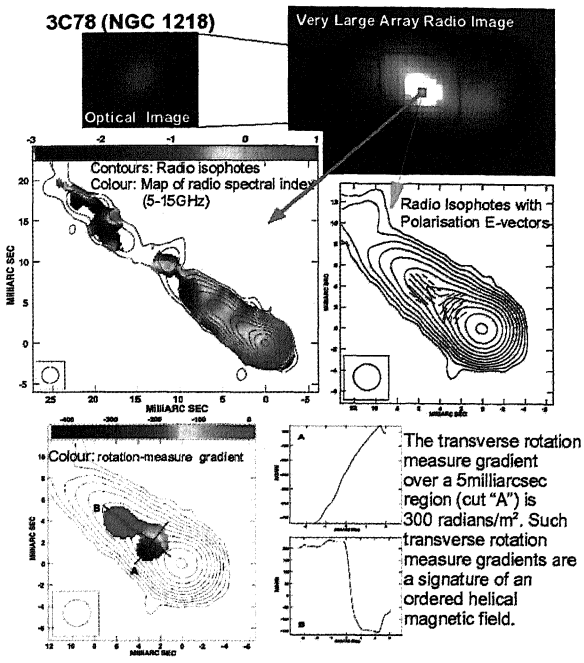


Figure 1.32: The radio image on kiloparsec scales shows, in addition to a bright nucleus, a jet towards the north-east and a fainter 'bent' counter-jet, both of which peter out without any bright terminal shocks (Fanaroff-Riley type I). The galaxy is an elliptical (top left). In the zoomed-in parsec-scale radio image obtained with very long baseline interferometry, apart from the north-eastern nuclear jet, a very small faint counter-jet is also clearly discernible because of it being optically thin (bluish-green: steep spectrum) as against the optically thick nucleus (red: flat spectrum). The polarisation E-vectors have effects of Faraday rotation removed.

(P. Kharb, D. C. Gabuzda*,, C. O'dea*, , P. Shastri & S. Baum*)*

How different are Be stars in the Magellanic Clouds ?

Various types of Be star candidates in LMC and SMC are studied by correlating their optical and near-infrared properties. Mennickent et al. (2002) presented a catalogue of 1056 Be star candidates in the Small Magellanic cloud (SMC) by studying light curve variation using OGLE II data base. They classified the Be star candidates of SMC in four categories: Type 1 stars showing outbursts;Type 2 stars showing sudden luminosity jumps; Type 3 stars showing periodic or near periodic variations; Type 4 stars showing light curves similar to Galactic Be stars. Based on a similar inspection of OGLE II data, Sabogal et al. (2005) classified Be candidates in LMC also as Type1,Type 2, Type 3 and Type 4 stars. For LMC they studied a sample of 2446 stars. However most of the type 4 stars in LMC are found to be reddened and located parallel to the main sequence, this feature was not found in the same diagrams of SMC. The above studies identified a large number of candidate Be stars which can be used to derive the parameters as these types of stars in the MCs are metal poor when compared to the Galactic Be stars. The above classification was based only on photometric variability. It is desirable to get some more properties like their NIR magnitudes and colours. These can be used to confirm them as Be stars. For this purpose, we used the near infrared IRSF catalog. Our analysis shows a possible new sub class of Be stars in the LMC, which does not have any counterparts in the SMC or in our Galaxy. These stars could belong to a later spectral type, with no NIR excess and have variability very similar to the Galactic Be stars. Spectroscopic study of individual stars belonging to various types in LMC and SMC are in progress.

(Annapurni Subramaniam, K. T. Paul, Blesson Mathew, Ronald Mennickent*)*

Spin-down of black holes and cosmic evolution of AGN

The recently discovered apparent dramatic expansion in the effective radii of massive elliptical galaxies from $z \simeq 2$ to $z \simeq 0.1$ has been interpreted in terms of either galaxy mergers or the rapid loss of cold gas due to AGN feedback. In examining the latter case, the extent of the expansion has been quantified, which is uncertain observationally, in terms of the star formation parameters and time of the expulsion of the cold gas. In either case, the large global decrease in stellar density should translate into a major drop in the ISM density and pressure, and a much steeper radial decline in those quantities with cosmic epoch. These cosmological changes are expected to have a major influence on the gas accretion mode, which will shift from 'cold' thin disk accretion at high redshifts toward 'hot' Bondi fed ADAF accretion at low redshifts. The decline of angular momentum inflow would then lead to a spin down of the black

hole, for which more precise timescales have been calculated; a value of about 0.2 Gyr is typical for a $10^9 M_\odot$ central black hole. These results have implications for the different cosmological evolutionary patterns found for the luminosity functions of powerful and weak radio galaxies.

(A. Mangalam, Gopal-Krishna & P. J. Wiita*)*

Black hole entropy

A unified picture of black hole entropy and curvature was developed and this was shown to lead to Hawking radiation. Some invariant underlying relations connecting curvature with Hawking luminosity and temperature were studied. The volume inside the horizon, apart from the horizon surface, could also play a role in understanding the Hawking flux. Holography implies a phase space associated with the interior volume and this happens to be just a quantum of phase space filled with just one photon. Generalised uncertainty principle is also incorporated in this analysis. Results hold for all black hole masses in any dimensions.

(C. Sivaram & Kenath Arun)*

Black holes and the LHC

The detailed aspects of the relevant physics for the possible formation of black holes in the Large Hadron Collider have been considered. In this context, the physical principles involved in the cosmological formation of primordial black holes in the conditions prevailing in the early universe has also been invoked and applied to the present situation. The properties of TeV black holes in extra dimensions are also being studied in this context. It has been concluded that the possibility of any disaster arising from the formation of black holes in LHC is totally unfounded.

(C. Sivaram)

Thermal gravitational waves

Several aspects of the generation of thermal gravitational waves (radiation) of high frequency, in compact astrophysical objects and high energy sources such as gamma ray bursts including beaming effects has been studied. Consequences of such processes are also examined. The integrated thermal gravitational radiation background from such objects as well as from high energy processes in the early universe has been considered. New methods for detecting such radiations is also under study.

(C. Sivaram & Kenath Arun)*

Jets in astrophysics

The current understanding of the formation of powerful bi-directional jets in systems such as radio galaxies and quasars is that the process involves a supermassive black hole that is being fed with magnetized gas through an orbiting accretion disk. The authors discuss the dynamics of the jet, powered by rotating black holes, in the presence of a magnetic field, including the scaling of the jet length and their typical timescales. They consider a unified picture covering all phenomena involving jets and rotating black holes ranging from gamma ray bursts to extragalactic jets and discuss the relevant scaling laws. The authors have also discussed the acceleration of the particles in jets and consequent synchrotron and inverse Compton radiations. Accelerated protons from jets as possible sources of high energy cosmic rays are also discussed.

(C. Sivaram & Kenath Arun)*

Intermediate mass black holes

There is a lot of current astrophysical evidence and interest in intermediate mass black holes (IMBH), ranging from a few hundred to several thousand solar masses. The active galaxy M 82 and the globular cluster G1 in M 31, for example, are known to host such objects. Here the authors discuss several aspects of IMBHs such as their expected luminosity, spectral nature of radiation, associated jets, etc. They also discuss possible scenarios for their formation including the effects of dynamical friction, gravitational radiation, etc. They also consider their formation in the early universe and also discuss the possibility of supermassive black holes forming from mergers of several IMBH and compare the relevant timescales involved with other scenarios.

(C. Sivaram & Kenath Arun)*

Dark energy: A brief history

Many earlier contributions and predictions by the present author for the expected dominance of dark energy at the present cosmic epoch including constant and time varying cosmological constants has been elucidated and reviewed with the relevant quan-

titative values of the various parameters. These are all in good agreement with currently observed values. A comparative study of unified pictures of both dark energy and dark matter and their future evolution is also being studied.

(C. Sivaram)

Unveiling the nature of Seyfert galaxies X-ray spectra

Seyfert galaxies are low-luminosity nearby active galaxies powered by accretion onto supermassive black holes (SMBH) residing at their center. Seyfert galaxies are mainly classified into types 1 and 2, based on the presence or absence of broad permitted emission lines in their optical spectra, respectively (Antonucci, R., 1993, ARA&A 31, 473A. The unification scheme for Seyfert galaxies hypothesizes that Seyferts 1 and 2 are of the same parent population and appear different, solely due to differing orientations of dusty molecular obscuring material around the nucleus. The X-ray photons originated from the nucleus can transmit through the obscuring torus and X-ray spectral analysis can give the estimate of the amount of obscuration along the observer's line-of-sight. The authors study the X-ray spectral properties of a rigorously selected sample of Seyfert galaxies in 0.5 – 10.0 ke V band using XMM-Newton observations. They find that Seyfert galaxies' X-ray continuum spectra in 0.5 – 10.0 keV energy range can be characterized by an absorbed power law often having an excess emission over power law at the soft end and a reflection component at the hard end of the spectra. Fluorescent Fe Kα emission line at 6.4 keV is also seen in the X-ray spectrum of many Seyfert galaxies. The primary aim of this study is to test the predictions of the Seyfert unification scheme using the X-ray spectral properties. The preliminary results of the study are broadly consistent with the unification scheme.

(Veeresh Singh, Prajval Shastri & Guido Risaliti)*

Characteristics of low-frequency radio emission from Seyfert galaxies

Seyfert galaxies are low-luminosity, radio-quiet (ratio of the radio flux at 5.0 GHz to the optical flux in B-band is less than 10), nearby active galaxies. The high-frequency radio observations of several Seyfert galaxies show jet-like features, which tend to be confined within the host galaxy, whereas low frequency observations reported in the literature show more extended radio emission. GMRT observations at 610 MHz, 240 MHz and VLA observations at 1.4 GHz are being used to investigate the characteristics of low-frequency radio emission, i.e., structure and spectral properties of Seyfert galaxies in the framework of Seyfert unification scheme.

(Veeresh Singh, Prajval Shastri & Ramana Athreya)*

1.5 Atomic Physics

Reappraisal of *cis* effect

Relative stabilities of 1,2-difluoroethene and 1,2-dichloroethene isomers are studied on the basis of chemical hardness (η) and electrophilicity (ω) using the principles of maximum hardness and of minimum electrophilicity. The chemical hardness and electrophilicity deduced from our proposed method called "improved virtual orbitals" (IVO) orbital energies predict that *cis* 1,2-difluoroethene and 1,2-dichloroethene are energetically more stable than the corresponding *trans*-isomers and is in accord with experiment.

(R. K. Chaudhuri)

Calculation of the scalar and pseudo-scalar interaction constant W_S

The P,T-odd interaction constant, W_S, for the ground state of YbF and BaF molecules are calculated using the second order many-body perturbation theory (MBPT) via Z-vector technique. The interaction constant W_S reported here agrees favorably well with other correlated calculations. The convergence behavior of W_S with respect to the number of active orbitals used is also addressed.

(R. K. Chaudhuri)

Atomic astrophysics

A knowledge of atomic polarizabilities is necessary for several situations in astophysics. However, it is challenging to perform accuarate calculations of these quantities, particularly for heavy atoms where the interplay between relativistic and correlation effects are important. The relativistic coupled-cluster theory has been used to calculate the polarizabilities of a number of closed shell atoms ranging from helium to ytterbium. The polarizability and the van der Waals coefficients for lithiumhave also been calculated using a novel approach.

(B. P. Das & B. K. Sahoo)*

Ultracold atoms

The superfluid to Mott insulator transition in a Bose ladder consisting of two coupled chains has been successfully studied and arrived at some important conclusions. In particular, it was found that this transition occurs at a larger value of the onsite interaction than in the case of a one dimensional chain.

The various signatures have been analysed for the superfluid to Mott insulator transition in a one dimensional optical lattice in the presence of a trap.

(Tapan Mishra, B. P. Das, Meetu Sethi, R. V. Pai & Sunethra Ramanan*)*

Non-accelerator particle physics

Significant progress has been made in the research on the relativistic many-body theory of the electric dipole moments(EDMs) of both paramagnetic and diamagentic atoms. The work on the EDMs of rubidium and caesium has been published in the Physical Review Letters. The calculation of the electron EDM enhancement in thallium have been considerably improved and obtained a new limit for the electron EDM. Attempt are being made to improve it even further.

The EDM of the diamagnetic atom, Hg is now at a very crucial stage. New results are expected fairly soon which can be combined with the latest experimental data on the EDM of this atom to extract a number of different CP violating coupling constants.

The work initiated on the parity nonconservation(PNC) in Ra+ due to neutral weak currents has now borne fruit. An accurate result has been achieved for the PNC amplitude of the transition from the ground to the first excited D state which will be useful for the experimentalists who plan to observe it in order to test the standard model of particle physics.

The relativistic configuration interaction method has been used to carry out a theoretical analysis of the nuclear anapole moment in BaF. The result obtained will be used as an input for an experiment to observe this quantity at Yale University, USA. The nuclear anapole moment can provide unique insights into PNC in nuclei.

(H. S. Nataraj, B. P. Das, B. K. Sahoo, D. Mukherjee* & M. K. Nayak*)*

1.6 Optical Sciences

Wavefront sensing for adaptive optics

The main objective of this research work has been to develop a novel wavefront sensing technique using Polarization Shearing Interferometer (PSI) for the evaluation of the wavefront errors in a closed loop adaptive optics environment. Shearing interferometry is one of the techniques to measure wavefront phase through intensity measurements. The basic approach is to produce an interference pattern between the wavefront and a sheared or displaced replica of itself. In this way, the phase variations, which cannot be measured directly because of its high temporal frequency, are converted into intensity variations (fringe pattern) in the pupil plane. One of the efficient ways to produce a shearing interferometric record is by using bi-refringent prisms like the Babinet compensators. Two dimensional shear was achieved by placing two crossed Babinet Compensators on either side of the focus. The Fourier theory for the same was developed and reported. Theoretical investigations were carried out using Zernike polynomial. The effects of atmospheric turbulence on the fringes were simulated theoreticaly with varying conditions, noise and ripples and the results were presented. An appropriate method to retrieve the wavefront error information from a single interferogram has been developed. Fourier Transform method has been suitably adopted for this analysis. A detailed study of phase retrievel methods has been presented in this work.

An unique optical configuration has been worked out where shearing interferometric wavefront sensor and the Shack Hartmann wavefront sensor can be located in the optical path and the experiments were conducted concurrently. The atmospheric turbulence was simulated by introducing a locally constructed phase plate. The aim of the experiment is to evaluate the phase plate and compare the results with other wavefront sensing methods. The phase plate was earlier calibrated using Zygo interferometer. The software for the data reduction was written in LabView and the results were presented in the thesis. The results were verified by conducting a Shack Hartmann sensor in the same environment and compared. Both the results agree. Finally the advantages of the shearing interferometer for adaptive optics applications in terms of high spatial sampling and sensitivity were discussed.

(J. P. Lancelot & A. K. Saxena)

Sharpening the blur: Wavefront sensing and correction using spatial light modulators

In the optics laboratory at the CREST campus of IIA, an unconventional wavefront sensing device, viz., the liquid crystal spatial light modulator, was successfully tested for its ability to retrieve the phase of an incident wavefront of light, with the ultimate aim of using such devices to improve telescope image quality through Adaptive Optics (AO) techniques.

AO techniques attempt to correct in real-time, distortions in the wavefront of the light incident on a telescope. These distortions arise because of non-uniformities in the propagating medium. AO assemblies require a wavefront sensor, a wavefront corrector and a control algorithm.

The spatial light modulator (SLM) is a pixelated device, which can modulate the phase and amplitude of an incident wavefront of light. Although not commonly used for wavefront correction, it has advantages of high resolution, phase reliability, compactness and ease of operation, among others. The SLM can also be used as a wavefront sensor by addressing its pixels in such a way that it behaves as a Hartmann mask. Conventionally, wavefront sensing uses a static lenslet array in a Shack-Hartmann sensor. In the experiments at IIA, on the other hand, an electrically addressed 2-D matrix of diffractive optical lenses was used. Standard centroiding and reconstruction algorithms were implemented on SLMs test their phase retrieval ability (see Fig. 1.33).

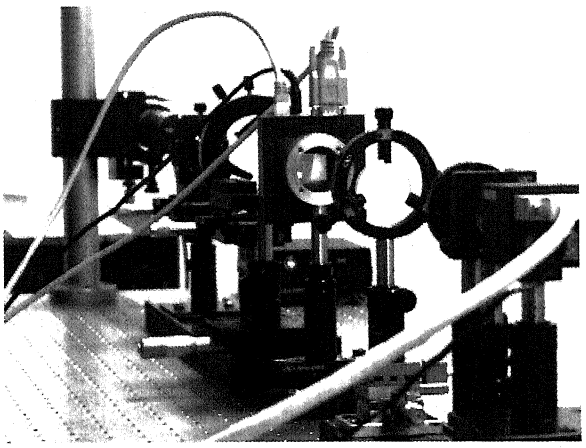


Figure 1.33: The experimental set up where the spatial light modulator is used as a Shack-Hartman sensor.

Spatial light modulators LC-2002, Hex-127 and LC R-720 were characterized for their phase response as a function of the applied gray-scale. A resolution chart was used as an object and known Zernike aber-

rations were imposed in the path of the beam using LC-2002 SLM. The aberrations were compensated by imposing the corresponding Zernike conjugate on Hex-127 SLM. The original (without aberration), distorted and compensated images were recorded and the improvement in the Strehl ratios can be seen in the histogram shown in Fig. 1.34.

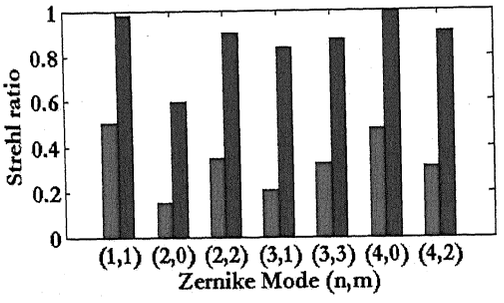


Figure 1.34: The improved quality of th corrected image.

By projecting an array of Fresnel zone plates, the SLM LC-2002 was used as a wavefront sensor. LC R-720 was used for the tilt production of different magnitudes across a single sub-aperture of the sensor and the corresponding position of the focal spot was measured using the iteratively weighted centroiding technique. Within experimental errors the behavior of the sensor was found to be linear with the applied phase differences as shown Fig 1.35.

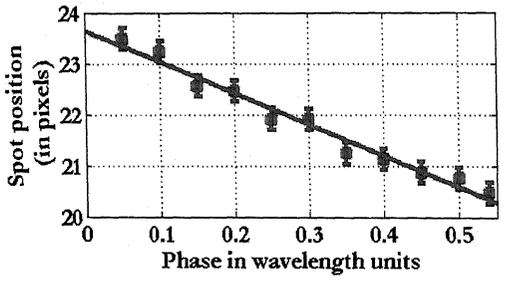


Figure 1.35: The position of the focal spot showing a linear relationship with the applied phase.

A long focal length digital lenslet array was simulated by addressing the calculated phase profile under a thin lens and paraxial approximation. This lenslet array also showed a linear behaviour with the applied phase. Both the lenslet arrays were calibrated for their alignment errors and temporal instabilities.

Phase retrieval from slope measurements was performed using the Vector Matrix Multiply algorithm (VMM) and Fourier methods for different sampling geometries. Sampling geometries suggested by Hudgin, Fried and Southwell were studied. Monte-Carlo simulations were performed to evaluate the performance of the phase reconstruction algorithms. Simulations consist of the generation of phase screens of different coherence length, estimating the effect of placing a Shack-Hartman Sensor, measurement of slopes from the obtained spot pattern, evaluating phase screens via the correlation coefficient. The VMM reconstructor performed best for Shack-Hartmann geometry with 85 % correlation. The Fourier method gave 79 % correlation for the same geometry and was faster compared to VMM method and found to be less sensitive to sensor resolution.

There is always a finite time delay in wavefront correction after sensing, called the servo lag error, which makes it increasingly harder to follow the distortions induced by rapidly varying atmospheric conditions in a closed loop.

A possible solution to this problem is to progressively predict future wavefronts from the information of the immediate past. This prediction helps in improving the performance of adaptive optics systems. A prediction technique for atmospherically distorted phase screens was developed using time-series data mining and was tested. The prediction technique developed shows an improvement of 6% over correction without prediction. These results were presented at the 27th Astronomical Society of India Meeting, February 2009, Bangalore, and at the conference "Trends in Optics and Photonics", March 2009, University of Calcutta.

(Akondi Vyas, M. B. Roopashree, Ravinder Banyal & B. R. Prasad)

Laboratory adaptive optics

The authors explore the possibility of using a Spatial Light Modulator (SLM) as a wavefront corrector and wavefront sensor. SLM is a nonlinear device. It is not possible to use all the grayscale values because of the nonlinearity of the SLMs. To use all the gray levels, the authors need to use inverse transformation of the interpolation relation between grayscale to phase which allows them to incorporate the nonlinearity of the spatial light modulator. Hence it is important to characterize these devices for their phase response before they can be used for wavefront correction.

All the SLMs in the lab (Holoeye LC 2002, Meadowlark Optics Hex 127 and HOLOEYE LCR 720) were characterized for their nonlinearity and phase production for best performance using interferome-

try. The phase compatibility of the SLMs for phase production and compensation was checked. The maximum phase obtained using the SLMs were measured using a Mach Zehnder and Twymann Green interferometric setups.

Zernike polynomials are widely used for representing aberrations of an optical system. The need for quantification of wavefront aberration requires the computation of the Zernike moments which weigh each of the Zernike polynomials. Many algorithms exist for computation of these moments. The direct method which uses mathematical definition of the Zernike polynomials will not allow fast computation. Recurrence relationships have been developed by some authors earlier, each of which has its advantages and disadvantages. Recently, Hosny proposed a fast and accurate method of computing Zernike moments. This method minimizes the geometrical errors by a proper mapping of the image and the approximation errors are removed by using exact Zernike moments for reconstruction of the image. The authors have implemented Hosny's method of representing images using Zernike polynomials.

The authors have generated and corrected the Zernike aberrations imposed on an image using two SLMs. They have produced different Zernike aberrations using the LC2002 Holoeye SLM. Wavefront correction is achieved by imposing phase corrections on the second SLM which is a Meadowlark Optics Hex127 SLM. Both of these SLMs are transmitting type SLMs. The correcting SLM was placed in the image plane of aberration generating SLM. Experiments were performed and the images were captured before and after the correction for comparison. A complete study of the effect of various aberrations and the images as they look after the imposition of Zernike aberrations has been done. The extent of correction has been quantified. The possibility of making an efficient adaptive optics system using two SLMs is explored. These results are published in the proceedings of the International Conference on Trends in Optics (IConTOP-2009).

It is also possible to use the spatial light modulator as a wavefront sensor. Diffractive Fresnel lenses have been generated and projected on the LC2002 SLM. By changing the parameters that govern the diffractive lens, the authors have generated diffractive lenses of different foci. Experimentally the focal lengths are measured and compared with the theoretical values. A very good correlation between the experimental and theoretical values have been seen. Many experiments were done to characterize the performance of SLM as wavefront sensor. The authors have studied the effect of small displacement of the detector around the focal point of the Fresnel lens. Also we studied the effect on the focal spot due to inclination of SLM to the incoming beam. These studies help us in understanding the error sources that should be taken into account while using SLM as wavefront sensor. As a first check for the proper operation of SLM they have introduced arbitrary aberration using a CD case to the light beam and sensed the wavefront in terms of local slopes using the above mentioned sensor setup and reconstructed the wavefront using standard least square wavefront reconstruction. The authors have moved the aberration producing plate to and fro and measured the wavefront. Wavefront in the two situations matched well within the experimental error.

The rigorous characterization of SLMs allowed the authors to apply wavefront tilt of different magnitudes across a single lens of the sensor. The relation between tilt magnitude and shift in the focal spot was found to be linear, well within the experimental error. This result provided evidence for the proper functioning of the sensor and the proportionality constant obtained here can be used for measurement of unknown wavefront phase.

To understand the behaviour of atmospheric turbulence, the authors have simulated phase screens following Kolmogorov statistics using Zernike polynomials. This was used in further laboratory experiments by projecting the phase screens on the SLM and numerical studies on wavefront reconstruction algorithms. The effect of the turbulence on the celestial objects was also simulated.

In most wavefront sensors they try to extract phase distortion information from slope measurements. They have studied different configurations of wavefront reconstruction from slope measurements. The least squares method of Fried, method of error minimization by Hudgin and the matrix method of Southwell were implemented and studied. The advantages of Fourier reconstructor were studied in comparison with these vector matrix multiplier methods. Random phase screens were simulated and the behaviour of a Shack Hartmann sensor was simulated. From the shifts of the foci, the authors have reconstructed the phase screens using the above studied methods.

The Shack Hartmann sensor is generally inflicted with Poisson noise, background noise and readout noise. These introduce large wavefront reconstruction errors (especially in sensors involving centroid estimation). Different centroiding algorithms – Normalized centroiding, Weighted centroiding, Itera-

tively Weighted centroiding and Correlation based centroiding techniques were implemented. The advantages and disadvantages of these techniques in the presence of background. These centroiding techniques were compared in the presence of low light level conditions also and it was shown that Iteratively Weighted centroiding technique out performs other techniques. A denoising procedure was suggested for Shack hartmann spot pattern images based on a thresholded Zernike reconstructor. Centroding becomes even more difficult while working with a Laser Guide Star as a reference. The problems of spot elongation in the presence of noise were studied and addressed using an improved Iteratively Weighted Centroiding technique.

The problem of servo lag is well known in adaptive optics. To reduce the effects due to these time lags in wavefront correction, many predictive algorithms were suggested by many othors. Here the authors have implemented and tested a simple data mining technique where a proper segmentation of the time series of the past can be used to extrapolate into the future. This mining technique was implemented on simulated Kolmogorov phase screens. Extrapolation was applied to the pixels of the phase screens and also independently to Zernike moments. The authors have showed a significant improvement (6% improved in Strehl ratio) in the wavefront correction.

It is critical to monitor the sky conditions in real time for best performance of the adaptive optical systems. Two simple and efficient image processing techniques based on Hough transforms and data mining were numerically tested using Kolmogorov phase screens to measure the coherence of optical wavefronts in real time. Wind speed was measured using correlation technique and the issues related to correlation timescales of turbulence were addressed.

(A. Vyas, M. B. Roopashree, Ravinder Kumar Banyal & B. Raghavendra Prasad)

Light Scattering by Random Systems

Scattering of light is recognized to be very important method in non-destructive contactless test. Light scattered by a rough surface carries signatures of the surface morphology of the reflector. Our investigations have essentially centered around the issue of detection of hidden periodic structures on the surface, which are subsumed by the randomness. The matched filtering method developed by us has clearly demonstrated the strength of the method in detecting very weak hidden periodicities by intensity measurements alone. In a recent work we have further justified the efficacy of this method by several statistical tests. The method developed above is being now applied in several important problems at hand. Firstly, the above method is extended for detection of multiple periodicities in the rough surface. Now theoretical and computational method for rough surface scattering have been developed, where the random elevations $\delta\xi(x,y)$ are modeled as 'zero' mean, stationary random Gaussian process with correlation as, $< \delta\xi(x_1,y_1) \cdot \delta\xi(x_2,y_2) >= \sigma^2 f(r)$ where $r^2 = (x_1 - x_2)^2 + (y_1 - y_2)^2$; $f(0) = 1$ and $f(r) = \exp[-(r/l)^\beta]$ with $1 \leq \beta \leq 2$. We have derived exact analytic formal expressions for the scattering cross-section. The motivation of this work lies in the potential application in various optical fabrications to be executed by the Institute. Rapid computational method valid over a range of parameter values are now being developed and experimental verification will be attempted shortly.

(V.C. Vani & S. Chatterjee)*

FPGA based design for CCD camera controller

A general purpose CCD controller that can address any make of CCD has been developed at the Indian Institute of Astrophysics. It is based on a Digital Signal Processor (DSP) chip, Motorola DSP 56002 for implementing essential operations such as read-out of the CCD, interfacing with the host and correlated double sampling for reset noise elimination. In order to reduce the chip count and size of the controller, a need has been felt to implement the design with the use of a Field Programmable Gate Array (FPGA) approach. Such an approach would not only be efficient but would also be able to enhance the image processing strategies. After examining the functionality of the DSP board, Bias and Clock board, Host Interface and Data Acquisition functions, an Algorithmic State Machine (ASM) is derived from the DSP code. The authors report the ASM design that has been used to design the system using the Hardware Description Language (HDL). Verilog HDL is used to create the code, which can be tested and debugged using Xlinx ISE software package. The authors also lists the advantages of using the FPGA here, and provide options for the hardware to be used.

(R. Srinivasan, K. Anupama, S. K. Saha & A. Rao)*

1.7 History of Astronomy

Michael Topping and the origin of the Madras Observatory

East India Company's Astronomer and Surveyor, Michael Topping was a major figure in establishing the Madras Observatory and promoting astronomy in India, in his short career of eleven years (1785 – 1796) in India. He played a key role in the formation, planning and erecting of the Madras observatory. He could convince the Company that the science of Astronomy is to be nurtured and promoted in India by establishing the observatory. He also played a role in other areas, such as the Survey and in establishing a school to train the surveyors.

(A. Vagiswari, N. K. Rao, P. Thakur & C. Birdie)

Megalithic Astronomy at Vibhuthihalli

Various astronomical aspects regarding the Megalithic Stone Alignments are being studied. In particular the alignment at Vibhuthihalli has been monitored for the sunrise and sunsets during the important times in the year. It is established that the lines of stones at Vibhuthihalli are indeed aligned to the Equinoxial sunrise (and sunset). Many other structural aspects of these Megalithic structures are also being studied in the context of measuring the passage of time.

(N. Kameswara Rao & Priya Thakur)

1.8 Publications

In Journals

*Abhishek Rai, Gaur, V. K., *Rai, S. S., *Priestley, K. 2008, Geophys. J. Int., 176, No. 2, 518
Seismic Signatures of the Pan-African Orogeny: Implications for Southern Indian High grade Teranes

*Abhishek Rai, *Rai, S. S., Gaur, V. K. 2008, Current Science, vol. 94, N0. 7, p. 911
Crustal Stress Patterns: Analysis of Ps Splitting for Seismic Anisotropy

*Anand, M. Y., *Kagali, B. A., Murthy, Jayant 2009, BASI, 37, 1
Study of Bubble Nebula using IUE High Resolution Spectra

Anupama, G. C., Sahu, D. K., Gurugubelli, U. K., Prabhu, T. P., *Tominaga, N., *Tanaka, M., *Nomoto, K. 2009, MNRAS, 392, 894
Optical Photometry and Spectroscopy of the Type Ibn Supernova SN 2006jc until the Onset of Dust Formation

*Arellano Ferro, A., Giridhar, S., *Rojas Lopez, V., *Figuera, R., *Bramich, D. M., *Rosenzweig, P. 2008, RMxAA, 44, 365
A New Search for Variable Stars in the Globular Cluster NGC 6366

Banerjee, D., *Peréz-Suárez, D., *Doyle, J. G. 2009, A&A(Letters) 501, L15
Signatures of Alfvén Waves in the Polar Coronal Holes as seen by EIS/Hinode

Banerjee, D., *Teriaca, L., Gupta, G. R., *Imada, S., *Stenborg, G., *Solanki, S. K. 2009, A&A(Letters), 499, L29
Propagating Waves in Polar Coronal Holes as seen by SUMER and EIS

*Barban, C., *Deheuvels, S., *Baudin, F., *Appourch aux, T., *Auvergne, M., *Ballot, J. P. *Boumier, *Chaplin, W. J., *García, R. A., *Gaulme, P., *Michel, E., *Mosser, B., *Régulo, C., *Roxburgh, I.W., *Verner, G., *Baglin, A., *Catala, C., *Samadi, R., *Bruntt, H., *Elsworth, Y., Mathur, S. 2009, A&A, (in press)
Solar-like Oscillations in HD 181420: Data Analysis of 156 days of CoRoT Data

*Benz, A. O., *Monstein, C., *Meyer, H., *Manoharan, P. K., *Ramesh, R., *Altyntsev, A., *Lara, A., *Paez, J., *Cho, K.-S. 2009, Earth, Moon & Planets, 104, 277
A World-Wide Net of Solar Radio Spectrometers: e-CALLISTO

Bharat, Y. K., Reddy, B. E. 2009, ApJL (in press)
HD 77361: A new case of super Li-rich K giant with anomalous low $^{12}C/^{13}C$ ratio

*Casse, B. D. F., Banyal, R. K., *Lu, W. T., *Huang, Y. J., *Selvarasah, S., *Dokmeci, M., *Sridhar, S. 2008, Applied Physics Lett., 92, 243122
Nano Engineering of a Negative-Index Binary-Staircase Lens for the Optics Regime

*Casse, B. D. F., *Lu, W. T., Banyal, R. K., *Huang, Y.J., *Selvarasah, S., *Dokmeci, M., *Perry C. H.,

*Sridhar S. 2009, Optics Letter, 34, 1994
Imaging with Sub-Wavelength Resolution by a Generalized Superlens at Infrared Wavelengths

*Chauhan, N., *Pandey, A. K., *Ogura K., *Ojha, D. K., Bhatt, B. C., *Ghose, S. K. 2009, *Rawat, P. S., 2009, MNRAS, 396, 964
Triggered Star Formation and Evolution of T-Tauri Stars in and around Bright Rimmed Clouds

Choudhury, R., Bhatt, H. C. 2009, MNRAS, 393, 959
Kinematics of the Young Stellar Objects Associated with the Cometary Globules in the Gum Nebula

*Foukal, Peter, *Bertello, Luca, *Livingston, William C., *Pevtsov, Alexei A., Singh, Jagdev, *Tlatov, Andrey G.; *Ulrich, Roger K. 2009, Solar Phys., 255, 229
A Century of Solar Ca ii Measurements and their Implication for Solar UV Driving of Climate

*Frisch, H., Anusha, L. S., Sampoorna, M., Nagendra, K. N. 2009, A&A, (in press)
The Hanle Effect in a Random Magnetic Field: Dependence of the Polarization on Statistical Properties of the Magnetic Field

*Geballe, T. R., Rao, N. K., *Clayton, G. C. 2009, Ap J, 698, 735
Do Hydrogen-Deficient Carbon Stars have Winds ?

*García, R. A., *Régulo, C., *Samadi, R., *Ballot, J., *Barban, C., *Benomar, O., *Chaplin, W. J., *Gaulme, P., *Appourchaux, T., Mathur, S., *Mosser, B., *Toutain, T., *Verner, G. A., *Auvergne, M., *Baglin, A., *Baudin, F., *Boumier, P., *Bruntt, H., *Catala, C., *Deheuvels, S., *Elsworth, Y., *Jiménez-Reyes, S. J., *Michel, E., *Pérez Hernández, F., *Roxburgh, I. W., *Salabert, D. 2009, A&A, (in press)
Solar-like Oscillations with Low Observed Amplitude in the CoRoT Target HD 181906

*Gomboc, A. et al. 2008, ApJ, 687, 443
Multiwavelength Analysis of the Intriguing GRB 061126: The Reverse Shock Scenario and Magnetization

Gupta, G. R., *O'Shea, E., Banerjee, D., *Popescu, M., *Doyle, J. G. 2009, A&A, 493, 251
On the Statistical Detection of Propagating Waves in Polar Coronal Holes

Gurugubelli, U. K., Sahu, D. K., Anupama, G. C., Chakradhari, N. K. 2008, BASI, 36, 79
Photometric and Spectroscopic Evolution of the Type II-P Supernova SN 2004A

*Hanasoge, S. M., *Couvidat, S., Rajaguru, S. P., *Birch, A. C. 2008, MNRAS, 391, 1931
Impact of Locally Suppressed Wave Sources on Helioseismic Travel Times

*Heintz, M., *Kumar, Gaur, V. K. 2009, Geophys. Jour. Int., RAS, (in press)
Anisotropy of the Indian Continental Lithospheric Mantle

Hiremath, K. M. 2009, Sun and Geosphere (in press)
Solar Forcing on the Changing Climate

Javaraiah, J. 2008, Solar Phys., 252, 419
Predicting the Amplitude of a Solar Cycle using the North - South Asymmetry in the Previous Cycle: an Improved Prediction for the Amplitude of Solar Cycle 24

Javaraiah, J., *Ulrich, R. K., *Bertello, L., *Boyden, J. E. 2009, Solar Phys., 257, 61
Search for Short-Term Periodicities in the Sun's Surface Rotation : A Revisit

Kamath, U. S., *Ashok, N. M., Anupama, G. C. 2008, BASI, 36, 141
Nova V4444 Sagittarii 1999 in the Early Decline and Quiescent Phases

Kariyappa, R. 2008, A&A, 488, 297
Solar Coronal Rotation Determination by X-ray Bright Points in Hinode/XRT and Yohkoh/SXT Full-Disk Images

Kariyappa, R., Varghese, B. A. 2008, A&A, 485, 289
Intensity Oscillations and Heating of the Coronal X-ray Bright Points from Hinode/XRT

*Kharb, P., *Lister, M. L., Shastri, P. 2008, Int. Jour. of Modern Physics D, 17, 1545
Magnetic Fields in Blazar Pc-Scale Jets – Possible Connection to Spin Rates of Black Holes ?

*Lanza A. F., et al. 2009, A&A, 493, 193
Magnetic Activity in the Photosphere of CoRoT-Exo-2a. Active Longitudes and Short-Term Spot Cycle in a Young Sun-Like Star

*Mahapatra, U. S., *Sudip Chattopadhyay, *Rajat K Chaudhuri 2008, J. Chem. Phys., 129, 024108
Molecular Applications of State-Specific Multi-reference Perturbation Theory to HF, H_2O, H_2S, C_2, and N_2 molecules

*Maheswar, G., Bhatt, H. C. 2008, Ap&SS, 2008, 315, 215
Enhanced Luminosity of Young Stellar Objects in Cometary Globules

Mangalam, A., *Gopal-Krishna, *Wiita, P. J. 2009, MNRAS, (in press)
The Changing ISM of Massive Elliptical Galaxies and Cosmic Evolution of Radio Galaxies and Quasars

Mathew, B., Subramaniam, A., Bhatt, B. C. 2008, MNRAS, 388, 1879
Be Phenomenon in Open Clusters: Results from a Survey of Emission-Line Stars in Young Open Clusters

Mathur, S., *García, R. A., *Eff-Darwich, A. 2009, ASSP, (in press)
Improving our Knowledge on the Dynamics of the Solar Core: Low-Degree High-Frequency p Modes and g Modes

*Messina, S., *Distefano, E., Parihar Padmakar, *Kang, Y.B., *Kim, S.-L., *Rey, S.-C., *Lee, C.-U. 2008, A&A, 483, 253
RACE-OC Project: Rotation and Variability in the Open Cluster NGC 2099 (M 37)

*Misra, K., Sahu, D. K., Anupama, G. C., *Pandey, K. 2008, MNRAS, 389, 706
Photometric and Spectroscopic Study of a Highly Reddened Type Ia Supernova SN 2003hx in NGC2076

*Mosser, B., *Roxburgh, I. W., *Michel, E., *Appourchaux, T., *Barban, C., *Baudin, F., *Boumier, P., *Bruntt, H., *Catala, C., *Deheuvels, S., *García, R. A., *Gaulme, P., *Régulo, C., *Samadi, R., *Verner, G., *Auvergne, M., *Baglin, A., *Ballot, J., *Benomar, O., Mathur, S. 2009, A&A, (in press)
CoRoT Sounds the Stars: HD 175726, a Simultaneously Active and Passive Star

*Munshi, Rahul, Prasad, B. R., Murthy, J. 2009, BASI, 37, 11
Design and Analysis of an FUV Spectrograph for a Small Satellite

Nagaraju, K.,*Sankara Subramanian, K., Rangarajan, K. E., Ramesh, K. B., Jagdev Singh, Devendran, P., Hariharan 2008, BASI, 36, 99
On the Performance of a Dual Beam Polarimeter at Kodaikanal Tower Telescope

Nataraj, H. S., *Sahoo, B. K., Das, B. P., *Mukherjee, D. 2008, Phys. Rev. Lett., 101, 03302
Intrinsic Electric Dipole Moments of Paramagnetic Atoms: Rubidium and Cesium

*Nayak, M. K., Chaudhuri, Rajat, K. 2008, Phys. Rev. A, 78, 012506
Calculation of the Electron-Nucleus Scalar-Pseudo-Scalar Interaction Constant W_s for YbF and BaF Molecules: A Perturbative Approach

*Nayak, M. K., Das, B. P. 2009, Phys. Rev. A (Rapid Communication), 79, 060502
Relativistic Configuration Interaction Study of the Nuclear Spin Dependent Parity Nonconserving Electron-Nucleus Interaction Constant W_A in BaF

Padmakar Parihar, *Sergio Messina, *Elisa, D., Shantikumar, N. S., *Biman J. Medhi 2009, MNRAS (in press)
Exploring Pre-Main Sequence Variables of ONC: The New Variables

Parihar Padmakar, *Messina, S., Bama, P., Medhi, B. J., Muneer, S., Velu, C., Ahmad, A. 2009, MNRAS, 410
Spectroscopic Survey of ASAS Eclipsing Variables: search for Chromospherically Active Eclipsing Binary Stars - I

*Polletta, M., *Omont, A., *Berta, S., *Bergeron, J., Stalin, C. S., *Petitjean, P., *Giorgetti, M., *Trinchieri, G., *Srianand, R., *McCracken, H. J., *Pei, Y., *Dannerbauer, H. 2008, A&A, 492, 81
Obscured and Powerful AGN and Starburst Activities at z 3.5

*Pottasch, S. R., Surendiranath, R., *Bernard-Salas, J. *Roellig, T. L. 2009 A&A, (in press)
Abundances in Planetary Nebulae: NGC 2792

Rajat K. Chaudhuri, *Karl, F. Freed 2008, J. Chem. Phys., 129, 054308
IVO-MRMP Study of the Ground and Excited Electronic States of Protonated Acetylene, $C_2H_3^+$

Raju, K. P. 2009, Solar Physics, 255, 119

Relative Velocities and Linewidths in a Coronal Hole and Outside

*Ramanan, S., Mishra, T., *Sethi Luthra, M., *Pai, R. V., Das, B. P. 2009, Phys. Rev. A, 79, 013625
Signatures of the Superfluid to Mott Insulator Transition in a One-Dimensional Optical Lattice

Ramesh, K. B., *Rohini, V. S. 2008, ApJL 686, L41
1-8 Å Coronal Background X-Ray Emission and the Associated Indicators of Photospheric Magnetic Activity

Ramesh, R., Kathiravan, C., Sundararajan, M. S., Barve, Indrajit V., *Sastry, Ch. V. 2008, Solar Phys., 253, 319
A Low-Frequency (30 110 MHz) Antenna System for Observations of Polarized Radio Emission from the Solar Corona

Rosario, M. J.,*Heckert, P. A., Mekkaden, M. V., Raveendran, A. V. 2009, MNRAS 394, 872
Spot Activity in the RS CVn Binary DM Ursae Majoris

Rosario, M. J., Mekkaden, M. V., Raveendran, A. V. 2008, IBVS No. 5836
UX Ari: New Photometry and Longitudinal Asymmetry in Spot Activity Fixed in Orbital Reference Frame

Safonova, M., Shalima, P., Murthy, J. 2009, BASI, 37, 23.
TAUVEX Flight Calibrations: Plans and Challenges

Safonova, M., Sivaram, C., Murthy, J. 2008, Ap&SS, 3318, 1.
Prospects for Observations of Transient UV Events with the TAUVEX UV Observatory

*Sahoo, B. K., Das, B. P. 2008, Phys. Rev. A, 77, 062516
Relativistic Coupled-Cluster Studies of Dipole Polarizabilities of Closed-Shell Atoms

*Sahoo, B. K., Das, B. P., Chaudhuri, R. K., *Mukh erjee, D., *Venugopal, E. P. 2008, Phys. Rev. A (Rapid Communication), 78, 010501
Atomic Electric Dipole Moments from Higgs Boson Mediated Interactions

Sahu, D. K., *Tanaka, Masaomi, Anupama, G. C., *Kawabata, Koji S., *Maeda, Keiichi, *Tominaga, Nozomu, *Nomoto, Ken'ichi, *Mazzali, P. A., Prabhu, T. P. 2008, ApJ, 680, 580
The Evolution of the Peculiar Type Ia Supernova SN 2005hk over 400 Days

Sampoorna, M., Nagendra, K. N., *Frisch, H. 2008, JQSRT, 109, 2349
The Hanle Effect with Partial Frequency Redistribution: Construction of Frequency Dependent Polarization Matrix and Numerical Solution by a PALI Method

Sampoorna, M., *Stenflo, J. O., Nagendra, K. N., *Bianda, M., *Ramelli, R., & Anusha, L. S. 2009, ApJ, 699, 1650
Origin of Spatial Variations of Scattering Polarization in the Wings of the Ca I 4227 Åline

Sengupta, S. 2008, ApJ Lett., 683, L195
Cloudy Atmosphere of the Extra-solar Planet HD189 733b : A Possible Explanation of the Detected B-band Polarization

Sethi Luthra, M., Mishra, T., *Pai, R. V., Das, B. P. 2008, Phys. Rev. B, 78, 165104
Phase Diagram of a Bosonic Ladder with Two Coupled Chains

*Shaikh, Y. H., *Khan, A. R., *Iqbal, M. I., *Behere, S. H., Bagare, S. P. 2008, Fractals, 16, 259
Sunspots Data Analysis Using Reported Time Series of Observations

*Sinha Mahapatra, U., *Chattopadhyay, S., Chaudhuri, R. K. 2009, J. Chem. Phys., 130, 014101
Application of State Specific Multireference Moller-Plesset Perturbation Theory to Non-Singlet States

Sivaram, C. 2009, Ap&SS, 319, 3
A Brief History of Dark Energy

Srinivasa Rao, M. 2009, Publ. Astr. Obs. Belgrade, 86, 59
Discrete Space Theory of Radiative Transfer : Applications

Srinivasa Rao, M., Varghese, B. A. 2009, Ser. Astr. J, 178, 49
Theoretical Study of Irradiation Effects in Close Binaries

*Sriramachandran, P., Bagare, S. P., *Rajamanickam, N., *Balachandra Kumar, K. 2008, Solar Physics, 252, 267
Presence of LaO, ScO and VO Molecular Lines in Sunspot Umbral Spectra

*Sriramachandran, P., Bagare, S. P., *Rajamanickam, N., Raja, V. 2009, Astroparticle Phys., 31, 6
On the Search for BF, BH and BS Molecular Lines in Sunspot Umbrae

*Sriramachandran, P., *Shanmugavel, R., Bagare, S. P., *Rajamanickam, N. 2009, Astrophys. Sp. Sc., 323, 41
Identification of SrF Molecular Lines in the Spectra of Sunspot Umbrae

*Sriramachandran, P., *Shanmugavel, R., *Rajamani ckam, N., Bagare, S. P., Romanian Astr. J. 2008, 18, 21
Evaluation of Astrophysically Useful Parameters for LaO Molecule

Stalin, C. S., Hedge, M., Sahu, D. K., Parihar, P. S., Anupama, G. C., Bhatt, B. C., Prabhu, T. P. 2008, BASI, 36, 111
Night Sky at the Indian Astronomical Observatory During 2000 – 2008

Stalin, C. S., *Kawabata, K. S., *Uemura, M., *Yoshida, M., *Kawai, N., *Yanagisawa, K., *Shimizu, Y., *Kuroda, D., *Nagayama, S., *Toda, H. 2009, MNRAS (in press)
Simultaneous MITSuME g′ R_cI_c Monitoring of S5 0716+714

Stalin, C. S., *Petitjean, P., *Srianand, R., *Fox, A.J., *Coppolani, F., *Schwope, A. 2009, MNRAS (in press)
Optical Identification of XMM Sources in the CFHTLS

Subramanian, S., Subramaniam, A. 2009, A&A, 496, 399
Depth Estimation of the Large and Small Magellanic Clouds

*Sudip Chattopadhyay, Rajat K. Chaudhuri *Uttam Sinha Mahapatra 2008, J. Chem. Phys., 129, 244108
Application of Improved Virtual Orbital based Multireference Methods to N_2, LiF, and C_4H_6 Systems

Sujatha, N. V., Murthy, J., Karnataki, A., *Henry, R. C., *Bianchi, L. 2009, ApJ, 692, 1333
GALEX Observations of Diffuse UV Radiation at High Spatial Resolution from the Sandage Nebulosity

*Tanaka, M., *Tominaga, N., *Nomoto, K., *Valenti, S., Sahu, D. K., *Minezaki, T., *Yoshii, Y., *Yoshida, M., Anupama, G. C., *Benetti, S., and 4 co-authors 2009, Ap J, 692, 1131
Type Ib Supernova 2008D Associated With the Luminous X-Ray Transient 080109: An Energetic Explosion of a Massive Helium Star

*Tlatov, Andrey G., *Pevtsov, Alexei A., Singh, Jagdev 2009, Solar Phys., 255, 239
A New Method of Calibration of Photographic Plates from Three Historic Data Sets

*Tominaga, N. et al. 2008, ApJ, 687, 1208
The Peculiar Type Ib Supernova SN 2006jc: A WCO Wolf-Rayet Star Explosion

*Turck-Chièze, S., *Brun, A. S, *García, R. A., *Jiménez-Reyes, S. J., *Pallé, P. L., *Salabert, D., *Ballot, J., Mathur, S. 2009, ASSP (in press)
Towards a Complete View of the Solar Internal Magnetism

*Turck-Chiéze, S., Hasan, S. S. et al. 2009, Exp. Astr., 23, 1017
The DynaMICCS perspectives

*Updike, A. C., et al. 2008, ApJ, 685, 361
The Rapidly Flaring Afterglow of the Very Bright and Energetic GRB 070125

*Vani, V.C. & S. Chatterjee 2008, Pramana, 70, 875
Scattering of light by a periodic structure, in presence of randomness VII: application of statistical detection test

Vasundhara, R. 2009, Icarus, 204, 194
Investigations of the Pre-Deep Impact Morphology of the Dust Coma of Comet Tempel 1

*Wansbeek, L. W., *Sahoo, B. K., *Timmermans, R. G. E., Das, B. P., *Mukherjee, D. 2008, Phys. Rev. A, 78, 012515
Ab Initio Determination of Polarizabilities and van der Waals Coefficeints in Li Atom using the Realtivistic Coupled-Cluster method

*Wansbeek, L. W., *Sahoo, B. K., *Timmermans, R.

G. E., *Jungmann, K., Das, B. P., *Mukherjee, D. 2008, Phys. Rev. A (Rapid Communication), 78, 050501
Atomic Parity Nonconservation in Ra+

*Yadav, R. K. S., *Kumar, B., Subramaniam, A., *Sagar, R., Mathew, B. 2008, MNRAS, 390, 985
Optical and Near-Infrared Photometric Study of the Open Cluster NGC 637 and 957

In Proceedings

*Acharya, B. S. et al. (for HAGAR Team) 2009, in "Very High Energy Phenomena in the Universe", Proc. 44 "Rencontre des Moriond La Thuile", Val d'Aosta, Italy.
Status of HAGAR Experiment at Hanle in the Himalayas

Akondi Vyas, Roopashree, M. B., Ravinder Kumar Banyal, Raghavendra Prasad, B. 2009, in Proc. Intl Conf. on "Trends in Optics and Photonics", (eds.) Ajay Ghosh, Debesh Choudhury, p. 318
Spatial Light Modulator for Wavefront Correction

Akondi Vyas, Roopashree, M. B., Raghavendra Prasad, B. 2009, in Proc. Natl Conf. "Innovative Computational Intelligence & Security Systems", p. 400
Optimization of Existing Centroiding Algorithms for Shack Hartmann Sensor

Anupama, G. C. 2008, in "RS Ophiuchi (2006) and the Recurrent Nova Phenomenon", ASP Conference Series, 401, 31
The Recurrent Nova Class of Objects

Anupama, G. C. 2008, in "RS Ophiuchi (2006) and the Recurrent Nova Phenomenon", ASP Conference Series, 401, 251
One Year of Monitoring of the 2006 Outburst in Optical and Low Radio Frequencies

Anusha, L. S., Sampoorna, M., *Frisch, H., Nagendra, K. N. 2009, in "Magnetic Coupling between the Interior and the Atmosphere of the Sun", (eds.) S. S. Hasan & R. J. Rutten, Astrophysics and Space Science Proceedings, Springer-Verlag: Berlin Heidelberg (in press)
The Hanle Effect as Diagnostic Tool for Turbulent Magnetic Fields at the Solar Surface

Banerjee, D. 2009, in "Magnetic Coupling between the Interior and the Atmosphere of the Sun", (eds.) S. S. Hasan & R. J. Rutten, Astrophysics and Space Science Proceedings, Springer-Verlag: Berlin Heidelberg (in press)
Waves in Polar Coronal Holes

Chatterjee, S., Banyal, R. K. 2009, in "Trends in Optics and Photonics", (eds.) A. Ghosh & D. Choudhury, University of Calcutta, p. 462
Scattering of Light by Rough Surfaces: High and Low Roughness Approximations

*Colombetti, P., *Taricco, C., *Bhandari, N., *Romero, A., Verma, N., *Vivaldo, G. 2008, in "Medical Imaging Conference and 16th Room Temperature Semiconductor Detector Workshop", Proc. Nuclear Science Symposium, Dresden, Germany (in press)
Experimental Set-up for Gamma-activity Measurements of Astromaterials

*Creevey, O. L., Mathur, S., *García, R. A. 2008, in "Solar-stellar dynamos as revealed by helio - and asteroseismology", Proc. GONG 2008/SOHO 21, Boulder, USA (in press)
Sensitivity of p Modes for Constraining Velocities of Microscopic Diffusion of the Elements

*Eyres, T. J. et al. 2008, in "RS Ophiuchi (2006) and the Recurrent Nova Phenomenon", ASP Conference Series, 401, 256
RS Ophiuchi: Radio Lightcurve Development following the 2006 Outburst

*García, R. A., Mathur, S., *González Hernández, I., *Jiménez, A. 2008, in "Solar-stellar dynamos as revealed by helio- and asteroseismology", Proc. GONG 2008/SOHO 21, Boulder, USA (in press)
Spatial Cross Spectrum: Reducing Incoherent Convective Backgroung of Resolved Helioseismic Instruments

Gaur, V. K. 2009, in "Turbulence, Dynamos, Accretion Discs, Pulsars and Collective Plasma Processes", (eds.) S. S. Hasan, R. T. Gangadhara, & V. Krishan, Astrophysics and Space Science Proceedings, Springer, p.85
Planetary Dynamos

Gaur, V. K. 2009, The Indian Lithosphere, Platinum Jubilee Volume of the Indian Academy of Sciences
The Indian Lithosphere

Giridhar, S. 2008, in "Nucleosynthesis in Stars",

Proc. of Kodai School, (eds.) Aruna Goswami& B. E. Reddy, Springer-Verlag (in press)
Spectral Classification; Old and Contemporary

Giridhar, Sunetra, *Gray, Richard O., *Corbally, Christopher J., *Bailer-Jones, *Coryn A. L., **Eyer, Laurent, *Irwin, Michael J., *Kirkpatrick, J. Davy, *Majewski, Steven, *Minniti, Dante, *Nordstrm, Birgitta 2008, in Transactions IAU, Volume 4, Issue 27A, Reports on Astronomy 2006 – 2009, ed. Karel van der Hucht, Cambridge: Cambridge University Press, p. 228
Commission 45: Spectral Classification – Triennial Report 2005 - 2008

Gupta, G. R., *O'Shea, E., Banerjee, D., *Popescu, M., *Doyle, J. G. 2009, in "Magnetic Coupling between the Interior and the Atmosphere of the Sun", (eds.) S. S. Hasan & R. J. Rutten, Astrophysics and Space Science Proceedings, Springer-Verlag: Berlin Heidelberg (in press)
On the Statistical Detection of Propagating Waves in Polar Coronal Hole

Hasan, S. S. 2008, in "Universal Heliophysical Processes", (eds.) N. Gopalswamy & D. F. Webb , IAU Symposium 257, Cambridge, p. 121
Processes in the Magnetized Chromosphere of the Sun

Hasan, S. S., Mallik, D. C. V., Bagare, S. P., Rajaguru, S. P. 2009, in "Magnetic Coupling between the Interior and the Atmosphere of the Sun", (eds.) S. S. Hasan & R. J. Rutten, Astrophysics and Space Science Proceedings, Springer-Verlag: Berlin Heidelberg (in press)
Solar Physics at the Kodaikanal Observatory: A Historical Perspective

Hiremath, K. M. 2009, in "Magnetic Coupling between the Interior and the Atmosphere of the Sun", (eds.) S. S. Hasan & R. J. Rutten, Astrophysics and Space Science Proceedings, Springer-Verlag: Berlin Heidelberg (in press)
Evershed Flow Velocities During 100 Years

Hiremath, K. M., *Akshatha, B. B. 2009, in "Magnetic Coupling between the Interior and the Atmosphere of the Sun", (eds.) S. S. Hasan & R. J. Rutten, Astrophysics and Space Science Proceedings, Springer-Verlag: Berlin Heidelberg (in press)
Thermal Structure of the Sunspots

*Jagadish Chandra Saraswatula, *Shuvan Prashant Turaga, Raghavendra Prasad, B., *Sivasankara Sai, S. 2009, in Proc. Intl Conf. on "Trends in Optics and Photonics", (eds.) Ajay Ghosh, Debesh Choudhury, p. 68
Optical Power Limiting in Bacteriorhodopsin and Azo-benzene Films

*Jagadish Chandra Saraswatula, *Shuvan Prashant, T., *Sivasankara Sai, S., Prasad, B. R. 2009, in Proc. Intl. Conf. on "Trends in Optics and Photonics", (eds.) Ajay Ghosh, Debesh Choudhury, p.9
Optical Limiting in Bacteriorhodopsin using a Four-state Model for Two-Beam Illumination

Kameswara Rao, N., Anibal Garcia-Hernandez*, David L. Lambert* 2008, in "Circumstellar Dust", Proc. of Heidelberg Conf., ASPC, 391, p. 25
Dust in R Coronae Borealis Stars – Study from our Spitzer Observations

*Kharb, P., *Gabuzda, D. C., *O'Dea, C. P., Shastri, P., *Baum, S. A. 2008, in "Radio Galaxies in the Chandra Era", Harvard-Smithsonian Center for Astrophysics, Cambridge, USA.
Pc-scale Rotation Measures Across Radio Galaxy Jets

Mathur, S., *Ballot, J., *Eff-Darwich, A., *García, R. A., *Jiménez-Reyes, S. J., *Korzennik, S. G., *Turck-Chièze, S. 2008, in "Solar-stellar dynamos as revealed by helio-and asteroseismology", Proc. GONG 2008/SOHO 21, Boulder, USA. (in press)
What Can We Learn on the Dynamics and the Structure of the Solar Core with g Modes ?

Mathur, S., *Jiménez-Reyes, J., *García, R. A. 2008, in "Solar-stellar dynamos as revealed by helio - and asteroseismology", Proc. GONG 2008/SOHO 21, Boulder, USA (in press)
GOLF: a New Proxy of Solar Magnetism

Muthu, C., *Maheswar, G., *Eswaraiah, C., *Pandey, A. K. 2008, IAU Symp., 251, 73
A Study of 2175 Absorption Feature with TAUVEX: An Indo-Israeli UV Mission

Nagendra, K. N., Sampoorna, M. 2009, in "Solar Polarization 5 – In Honor of Jan Olof Stenflo", (eds.) S. V. Berdyugina, K. N. Nagendra, & R. Ramelli, ASP Conf. Ser. 405 (San Francisco: ASP), 261
Numerical Methods in Polarized Line Formation Theory

Nagendra, K. N., Sampoorna, M., Anusha, L. S. 2009, in "Recent advances in Spectroscopy: Astrophysical, Theoretical and Experimental Perspective", (eds.) R. Chaudhary et al. Springer-Verlag, Heidelberg, Berlin (in press)
Recent Developments in Polarized Line Formation in Magnetic Fields

Pandey, G., *Lambert, D. L., Rao, N. K. 2008, in "Hydrogen-Deficient Stars", (eds.) Klaus Werner and Thomas Rauch, ASP Conf. Series, San Francisco: Astronomical Society of the Pacific, Vol. 391, p.35
Fluorine in R Coronae Borealis Stars

Ravindra, B., *Longcope, D. W. 2009, in "Magnetic Coupling between the Interior and the Atmosphere of the Sun", (eds.) S. S. Hasan & R. J. Rutten, Astrophysics and Space Science Proceedings, Springer-Verlag: Berlin Heidelberg (in press)
Evolution of Coronal Helicity in a Twisted Emerging Active Region

Reddy, B. E., *Lambert, D. L. 2009, in Proc. IAU Symp. 254, (eds.) J. Abdersen et al., Cambridge Univ. Press, p. 59, (CDROM)
The Galaxy Disk in Cosmological Context

Safonova, M., *Rahvar, S., *Bond, I., *Hearnshaw, J., Stalin, C. S. 2009, in "Observational Evidence for Black Holes in the Universe", Proc. 2nd Kolkata Conf., AIP Conf. Proc, Vol. 1053, p. 121 (2009)
Detection of IMBHs in Globular Clusters by Microlensing

*Salabert, D., *Turck-Chièze, S.,* Barrière, J. C., *Carton, P. H., *Daniel-Thomas, P., *Delbart, A., *García, R. A., *Granelli, R., *Jiménez-Reyes, S. J., *Lahonde-Hamdoun, C., *Loiseau, D., Mathur, S., *Nunio, F., *Pallé, P. L., *Piret, Y., *Robillot, J. M., *Simoniello, R. 2008, in "Solar-stellar dynamos as revealed by helio- and asteroseismology", Proc. GONG 2008/SOHO 21, Boulder, USA. (in press)
First Performances of the GOLF-NG Instrumental Prototype Observing the Sun in Tenerife

Sampoorna, M. 2009, in "Magnetic Coupling between the Interior and the Atmosphere of the Sun", (eds.) S. S. Hasan & R. J. Rutten, Astrophysics and Space Science Proceedings, Springer-Verlag: Berlin Heidelberg (in press)
Probability Density Functions to Represent Magnetic Fields at the Solar Surface

Sampoorna, M., Nagendra, K. N., *Stenflo, J. O. 2009, in ASP Conf. Ser. 405, "Solar Polarization 5 – In Honor of Jan Olof Stenflo", (eds.) S. V. Berdyugina, K. N. Nagendra, & R. Ramelli (San Francisco: ASP), 93
Theory of Polarized Scattering in the Mixed Hanle-Zeeman Regime

*Sawant, H. S., *Cecatto Jose, *Fernandes Francisco, Subramanian, K. R., *Maria Madsen, *Faria Claudio 2009, in the 37th COSPAR Scientific Assembly, 13 – 20 July 2008, Montreal, Canada, p. 2757
High Time Resolution Twenty Six Element Brazilian Decimetric (1.2 - 1.7, 2.8, 5.6) GHz, Array

*Nan, R., *Taylor, R., *Rodrguez, L.F., *Carilli, C., *Chapman, J., *Dubner, G. M., *Garrett, M., *Goss, W. M., *Hills, R. E., *Hirabayashi, H., Shastri, P., *Torrelles, J. M., in Transactions IAU, Volume 4, Issue 27A, Reports on Astronomy 2006 – 2009, ed. Karel van der Hucht, Cambridge: CUP, p. 331
Commission 40: Radio Astronomy – Triennial Report 2005 – 2008

*Shyam S. Rai, *Suryaprakasam, K., Gaur, V. K. 2009, in "Physics and Chemistry of the Earth's Interior", Indian National Science Academy's Platinum Jubilee Special volume, (eds.) A. K. Gupta and Somnath Dasgupta, Publ: INSA/SPRINGER
Seismic Imaging of the Mantle Discontinuities Beneath India: From Archaean Cratons to Himalayan Subduction Zone

Singh, J. 2008, AGUSMSP, 53B, 03
Solar Cycle Studies Using Ca-K line Spectroheliograms and Line Profiles obtained at Kodaikanal

Singh, V., Shastri, P. 2008, in "Observational Evidence for Black Holes in the Universe", (eds.) S. K. Chakrabarti & A. S. Majumdar, AIP Conf. Vol. 1053
X-ray Emission From Seyfert Galaxies: Surroundings of their Supermassive Black Holes

Singh, V., Shastri, P., *Athreya, R. 2009, in "Low Frequency Radio Universe", (eds.) D. J. Saikia et al., ASP Conf. Series, Vol. 407 (in press)
Low Frequency Radio Emission from Seyfert Galaxies

Sivaram, C. 2009, in Proc. IHY School, Kodaikanal Observatory, Dec. 2007, (eds.) S. S. Hasan & N. Gopalswamy, Springer (in press)
The Sun in the Universe

*Spite, Monique, *Corbally, Christopher J., *Dravins, *Dainis, Allen, Christine, *d'Antona, Francesca, Giridhar, Sunetra, *Landstreet, John D., *Parthasarathy, Mudumba 2008, in Transactions IAU, Volume 4, Issue 27A, Reports on Astronomy 2006 – 2009. ed. Karel van der Hucht, Cambridge: Cambridge University Press, p. 193
Commission 45: Spectral Classification – Triennial report 2006 – 2009

*Taam, R. E., *Deloy, C., Sengupta, S. 2009, In Pacific Rim Conf. on "Stellar Astrophysics", (eds.) B. Soonthornthum et al. (ASP :San Francisco), Vol. 404, 241
The Thermal Evolution of Mass Losing Donors in Am Cvn Binary Systems. Binary Systems

*Taricco, C., *Bhandari, N., *Colombetti, P., *Mariani, I., Verma, N., *Vivaldo, G. 2008, in Proc. of Memorie della Societa Astronomica Italiana, 75, 282
A Multiparametric HPGe-NaI Acquisition System for Low Gamma Activity measurements of Meteorites

*Taricco, C., *Bhandari, N., *Colombetti, P., *Romero, A., Verma, N. 2008, in Proc. Workshop on "The Origin of the Elements Heavier than Fe" in honour of the 70th birthday of Roberto Gallino, Torino, Italy, (in press)
Meteorites as Source of Information about Solar Activity in the Past

*Taricco, C., *Bhandari, N., *Colombetti, P., *Romero, A., Verma, N., *Vivaldo, G. 2008, in 52nd Congress della Societ Astronomica Italiana, Teramo, Italy (in press)
Ricostruzione Delle Variazioni Dellattivit Solare Nel Passato Mediante la Misura di Radioisotopi Cosmogenici in Meteoriti

Vigeesh, G., Hasan, S. S., *Steiner, O. 2008, in "Universal Heliopphysical Processes", (eds.) N. Gopalswamy & D. F. Webb , IAU Symposium 257, Cambridge, p. 185
Numerical Simulation of Wave Propagation in the Magnetic Network

*Witt, Adolf N., Murthy, Jayant, *Gustafson, Bo ÅS., *Baggaley, W. Jack, *Dwek, Eli, *Levasseur-Regourd, *Anny-Chantal, *Mann, Ingrid, *Mattila, Kalevi, *Watanabe, Jun-ichi 2008, Commission 21: 2008, IAUTA, 27, 171
Light of the Night Sky

*Yee Yee Oo, *Phyu Phyu San, Sampoorna, M., Nagendra, K. N., *Ramachandran, G. 2009, in "Solar Polarization 5 - In Honor of Jan Olof Stenflo", (eds.) S. V. Berdyugina, K. N. Nagendra, & R. Ramelli, ASP Conf. Ser. (San Francisco: ASP), vol. 405, p.119
Phase Matrices for Higher Multipoles of Scattering in External Magnetic Fields

In Books

Hasan, S. S. 2008, in "Physics of the Sun and its Atmosphere", (eds.) B. N. Dwivedi & Udit Narain, World Scientific, Singapore, p. 9
Overview of the Sun

Saha, S. K. 2008, in "Advanced Optoelectronic Materials and Devices", (eds.) P. Chakrabarti& S. Jit, MacMillan, New Delhi
Sensors for the High Resolution Astronomical Imaging

Saha, S. K. 2009, in "Trends in Optics and Photonics", (eds.) A. Ghosh & D. Choudhury, 305
Present Trends in Stellar Interferometry

Sivaram, C., *Kenath Arun 2009, *Modern Astronomy Startling Facts*, with 1001 Questions and Answers, 2009, Ane Books.

Sivaram, C. 2009, "Foundations of Sciences", (PH ISIC-CSC, New Delhi), Chapter 29, pp. 550 – 565
Aspects of Dark Energy and Black Hole Entropy

Books edited

Hasan, S. S., *Rutten, R. J. 2009, (eds.) "Astrophysics and Space Science Proceedings", Springer-Verlag: Berlin Heidelberg
Magnetic Coupling between the Interior and the Atmosphere of the Sun

Nagendra, K. N., *Berdyugina, S. V., *Ramelli, R. 2009, (eds.) "Solar Polarization 5 – In Honor of Jan Olof Stenflo", ASP Conf. Series, Vol. 405

Paper presentations in Meetings

Bagare, S. P. 2008, in "National Meeting on Total Solar Eclipse of July 22, 2009", June 23, 2008, IIA, Bangalore
Shadow Band Observations during Total Solar Eclipses

Birdie, C. 2009, in Proc.41st National Conference on "Conservation of Archival, Library and Media Material" Bangalore 22 – 24 January, 2009, Bangalore
Preserving for Future : Technology Issues

Sivaram, C., *Kenath Arun, *Samartha, C. A. 2008, in Int. Symp. "On Cosmology and Particle Astrophysics", National Taiwan University
Phase Space Constraints on Neutrino Luminosities

Srinivasan, R., Anupama, K., Saha, S. K., Aditya Rao* 2008, in 2nd National Workshop on "Advanced Optoelectronic Materials and Devices", December, 22 –24 2008
FPGA Based Design for CCD Camera Controller

Sundara Raman, K. 2009, in Inl conf. on "Recent Advances in Spectroscopy : Theoretical, Astrophysical, and Experimental Perspectives," IIA, Kodaikanal, January 28 – 31, 2009
Solar Spectroscopy at Kodaikanal Observatory

Sundara Raman, K. 2009, in "National Conference on Recent Advances in Solar Physics," Rev. Jacob Memorial Christian College, Ambillikkai, Dindigul, February 27 – 28, 2009
Solar Flares and Coronal Mass Ejections

Sundara Raman, K. 2009, in "National Conference on Global Networking,"Kodaikanal Christian College, Kodaikanal, September 19 - 20, 2008
Role of Computers in Astrophysics

Poster presentations in Meetings

Amit Shukla 2009, "27th ASI Meeting", IIA, Bangalore
Observation of the blazar 1ES 2344+514 with the HAGAR telescopes at Hanle

Ananta Charan Pradhan 2009, "27th ASI Meeting", IIA, Bangalore
Extinction Mapping Through Broad Band Photometry

Andrea Borch, *Rainer Spurzem, *Jarrod Hurley 2009, "27th ASI Meeting", IIA, Bangalore
Comparison of NBODY dynamical and stellar evolution models with integrated spectra of galactic globular clusters

Annapurni Subramaniam, *Giovanni Carraro, *Kenneth Janes 2009, "27th ASI Meeting", IIA, Bangalore
First photometric study of 10 northern clusters

Annapurni Subramaniam 2009, "27th ASI Meeting", IIA, Bangalore
CD Photometric study of three young open clusters with Be stars

Anupama, G. C., Krishna Prasad, S., Uday Kumar Gurugubelli 2009, "27th ASI Meeting", IIA, Bangalore
Spectral evolution of the classical nova V2491 Cygni

Anusha, L. S.,Sampoorna, M., *Frisch, H., Nagendra, K. N. 2008, "Magnetic Coupling between the Interior and the Atmosphere of the Sun", IIA, Bangalore, December 2 – 5, 2008
Hanle Effect as Diagnostic Tool for Solar Turbulent Magnetic Fields

*Arti Goyal, *Gopal Krishna, *Ram Sagar, *Santosh Joshi, Anupama, G. C. 2009, "27th ASI Meeting", IIA, Bangalore
Rapid optical variability of radio-intermediate quasars

*Arun Kenath, Sivaram, C. 2009, "27th ASI Meeting", IIA, Bangalore
Thermal gravitational waves

*Arun Kenath, Sivaram, C. 2009, "27th ASI Meeting", IIA, Bangalore
Some Aspects of Intermediate mass black holes

Aruna Goswami, *Subramania Athiray, Drisya, K., Sreeja S. Kartha 2009, "27th ASI Meeting", IIA, Bangalore
Abundances of neutron-capture elements in CEMP stars : A parametric model based study

Aruna Goswami, Sreeja S. Kartha, Selvakumar, G., Drisya, K. 2009, "27th ASI Meeting", IIA, Bangalore
Chemical compositions of Barium stars

Bagare, S. P., Hasan, S. S., Saxena, A. K., Samson, J. P. A., Rajendra B. Singh, Aditya, T., Sangita Padhy, Ann Mary Francis, Thubstan Dorjey, Namgyal Doorjey, Dorjai Tsewang, Angchuk Dorje, Rangarajan, K. E., Raju, K. P., Neeharika Verma, Vasanthraju, N., *Wahab Uddin, & Srivastava, A. K. 2009, "27th ASI Meeting", IIA, Bangalore
Study of day sky conditions at Hanle, Merak, and Devasthal for the proposed National Large Solar Telescope project

Bagare, S. P., Neeharika Verma, Shantikumar Singh, N., Rangarajan, K. E., *Erik J. Larson & Rajendra B. Singh 2009, "27th ASI Meeting", IIA, Bangalore
Sky radiometer observations at Hanle

*Bertello, L., *Ulrich, R. K., *Boyden, J. E., & Javaraiah, J. 2008, AGU, Spring Meeting 2008, abstract #SP53B-01
The Mount Wilson CaK Plage Index Time Series

*Bertello, L., *Ulrich, R. K., *Boyden, J. E., & Javaraiah, J. 2008, AGU, Spring Meeting 2008, abstract #SP13A-1503
The Solar Rotation Rate Profile from 1915 to 1985

*Bhargavi, S. G., Pati, A. K. 2009, "27th ASI Meeting", IIA, Bangalore
Comparative study of standard stars for UVIT / ASTROSAT

*Bhavani Prasad, J., *Santosh, P., Parihar, *Shylaja, B. S. 2009 "27th ASI Meeting", IIA, Bangalore
Simulation for Detection of Earth like ESP

Bhavya, B., Annapruni Subramaniam, Smitha Subramanian, Blesson Mathew 2009, "27th ASI Meeting", IIA, Bangalore
Duration of Star Formation in the Double Cluster h & chi Persei

Blesson Mathew, Annapurni Subramaniam 2009, "27th ASI Meeting", IIA, Bangalore
Spectroscopy of Be stars in young open clusters

Blesson Mathew, Annapurni Subramaniam 2009, "27th ASI Meeting", IIA, Bangalore
Spectroscopy of field CBe stars- A probe to understand Be phenomenon

*Chakali Eswaraiah, *Anil K Pandey, *Biman Jothy Medhi, Chinnathambi Muthumariappan 2009, "27th ASI Meeting", IIA, Bangalore
Broad band Optical Polarimetric Study of NGC1893

Gangadhara, R. T. 2009, "27th ASI Meeting", IIA, Bangalore
Role of rotation on the pulsar polarization

*Gebelle, T. R., Kameswara Rao N., *Clayton, G. C. 2009, "27th ASI Meeting", IIA, Bangalore
Do Hydrogen-deficient Carbon Stars have Winds ?

Girjesh Gupta, *Shea, E. O., Banerjee, D., *Popescu, M., *Doyle J.G. 2009, "27th ASI Meeting", IIA, Bangalore
On the statistical detection of propagating waves in polar coronal holes

Gupta, G. R. 2008, Evershed meeting on "Magnetic Coupling between the Interior and the Atmosphere of the Sun", IIA, Bangalore, December, 2 - 5 2008
On the Statistical Detection of Propagating Waves in Polar Coronal Hole

Hasan, S. S., Saxena, A. K., Bagare, S. P., Srinivasan, R., Sivaraman, K. R., Singh, J., K.E. Rangarajan, D. Banerjee, *Shankarasubramanian, K. 2009, "27th ASI Meeting", IIA, Bangalore
National Large Solar Telescope - a concept design

Hasan, S. S., Saxena, A. K., Bagare, S. P., Samson, J. P. A., Mohammed Ismail, M., Rajendra B. Singh, T. Aditya, R. Ismail Jabillulah, & Dorjai Tsewang 2009, "27th ASI Meeting", IIA, Bangalore
Development of Solar Differential Image Motion Monitor at IIA, for the NLST site characterization related to NLST program

Hiremath, K. M. 2009, "27th ASI Meeting", IIA, Bangalore
Magnetic field structure of the Mercury
Hiremath, K. M. 2008, Evershed meeting on "Magnetic Coupling between the Interior and the Atmosphere of the Sun". "Centenary Commemoration of the Discovery of the Evershed Effect", IIA, Bangalore, December 2 - 5, 2008
Evershed Flow Velocities During 100 Years

Hiremath, K. M., *Akshatha, B. B. 2008, Evershed meeting on "Magnetic Coupling between the Interior and the Atmosphere of the Sun". "Centenary Commemoration of the Discovery of the Evershed Effect", IIA, Bangalore, December 2 - 5, 2008
Thermal Structure of the Sunspots

Javaraiah, J. 2009, Evershed meeting on "Magnetic Coupling between the Interior and the Atmosphere of the Sun". "Centenary Commemoration of the Discovery of the Evershed Effect", IIA, Bangalore, December 2 - 5, 2008
Long-term Variations in the Solar Meridional Flow

Javaraiah, J. 2009, "27th ASI Meeting", IIA, Bangalore
Quasi 9-day periodicity in the solar differential rotation

Kamath, P. U. 2008, 8th Pacific Rim Conference on "Stellar Astrophysics (PRCSA 2008)," 5 - 9 May, 2008, Phuket, Thailand
Recovery of Quiescent Novae

Kameswara Rao N, Rekhesh Mohan, *David L Lambert 2009, "27th ASI Meeting", IIA, Bangalore
Circumstellar Atomic Hydrogen in Evolved Stars

Kameswara Rao, N., Priya Thakur, Venkata Manohara Reddy 2009, "27th ASI Meeting", IIA, Bangalore
Magelithic Astronomy in India-Vibhuthihalli

Kanniah Jayakumar, Chinnathambi Muthumariappan 2009, "27th ASI Meeting", IIA, Bangalore
Medium Resolution Spectroscopy of HR2095

Kanniah Jayakumar, Kameswara Rao N., Chinnathambi Muthumariappan Sriram, S. 2009, "27th ASI Meeting", IIA, Bangalore
High Spectral Resolution Studies of early type variables III. A - Canis Majoris star Gamma Peg

Kariyappa, R. 2009, "Magnetic Coupling between the Interior and the Atmosphere of the Sun", IIA, Bangalore, December 2 - 5, 2008
Bright Points in G-band and CaII H Images from Hinode and *Dynamical Evolution of X-ray Bright Points with Hinode/XRT*

Kariyappa, R. 2009, "27th ASI Meeting", IIA, Bangalore
Temperature Fluctuations in Solar X-ray Bright Points from Hinode/XRT Observations

*Kiran Gothe, Tushar Prabhu, *Nawang Dorje, *Varsha Chitnis 2009, "27th ASI Meeting", IIA, Bangalore
Pointing Model for HAGAR array of Telescopes

*Kumar, B., Muthu, C., *Singh, S. K., *Gupta, K. G. 2008, BASI, Proc. "25th ASI meeting", Special Volume, p. 82
Preliminary Optical Design of the 4m class Optical Telescope to be set up at Devasthal, Nainital as a National Facility

Mangalam, A., Paul J. Wiita, Gopal Krishna 2009, "27th ASI Meeting", IIA, Bangalore
Stellar core and properties of quasar black holes

Margarita Safonova, Shalima, P 2009, "27th ASI Meeting", IIA, Bangalore
TAUVEX Space Calibrations: Plans and Challenges

Mekkaden, M. V., Muneer, S., Raveendran, A. V. 2009, "27th ASI Meeting", IIA, Bangalore
Accretion variability in the Classical T Tauri star TW Hya

Muthumariappan, C. 2008, Proc. 25th ASI meeting, Special Volume, p. 50
Multiwavelengths Studies of Circumstellar and Interstellar Dust

Muthumariappan, C. 2009, "27th ASI Meeting", IIA, Bangalore
Three component model for ISM dust

Nagabhushana, S. 2009, "27th ASI Meeting", IIA, Bangalore
Mechanical configuration and design of Ultraviolet Imaging Telescope (UVIT)

*Neelam Chauhan, *Anil K. Pandey, *Ogura, K., *Ojha, D. K., Bhatt, B. C. 2009, "27th ASI Meeting", IIA, Bangalore
Triggered Star Formation and Disk Evolution in and around Bright-Rimmed Clouds

Padmakar Parihar, *Sergio Messina, *Elisa Distefano Shantikumar Singh, *Biman Medhi 2009, "27th ASI Meeting", IIA, Bangalore
Exploring pre-main sequence variables of ONC

*Paul, K. T., Annapurni Subramaniam, Blesson Mathew *Mennickent, R. E. 2009, "27th ASI Meeting", IIA, Bangalore
How different are the Be stars in the Magellanic Clouds ?

Raju, K. P., *Kamalam Vanninathan , Singh, J. 2009, "27th ASI Meeting", IIA, Bangalore

Studies of Solar activity from Kodaikanal Ca-K data

Ravindra, B. 2009, "27th ASI Meeting", IIA, Bangalore
Moving Magnetic Features Associated With an Emerging Active Region Near the Disk Center

Ravinder Banyal 2009, "27th ASI Meeting", IIA, Bangalore
Adaptive Optics for Large Telescopes

Reddy, E. 2008, "IAU 254", 9 – 14 June, 2008
Search for the Metal-Weak Thick Disk Component: Abundance Survey

Rekhesh Mohan, *Anish Roshi 2009, "27th ASI Meeting", IIA, Bangalore
HI 21 cm-line imaging of compact interstellar dark globules

Roopashree, M. B., Vyas, A., Ravinder Banyal, Raghavendra Prasad, B. 2009, "27th ASI Meeting", IIA, Bangalore
Spatial light modulator as Shack Hartmann wavefront sensor

Rumpa Choudhury, Harish C. Bhatt 2009, "27th ASI Meeting", IIA, Bangalore
Star formation in the bright rimmed cloud SFO 38 in IC 1396

Safonova, M., Prajval Shastri 2009, "27th ASI Meeting", IIA, Bangalore
Intermediate Mass Black Holes and Globular Clusters

Sengupta, S., et al. 2009, "27th ASI Meeting", IIA, Bangalore
On the Observational Signature of the Thermal State of Donors in AM CVn Binary Systems

*Shubhrangshu Ghosh, Mukhopadhyay, B., Vinod Krishan, *Manoranjan Khan 2009, "27th ASI Meeting", IIA, Bangalore
Disk Outflow coupled dynamics: Description of supercritical to sub-critical accretors

*Singh, S. K., Muthu, C., *Kumar, B., *Gupta, K. G. 2008, BASI, Proc. "25th ASI meeting", Special Volume, p. 78
Tolerance Analysis of the Optical Design of 4m Class Optical Telescope

Smitha Subramanian, Annapurni Subramaniam 2009, "27th ASI Meeting", IIA, Bangalore
Depth Estimation of the Large and Small Magellanic Cloud

*Sreejith Padinhatteeri, Ravindra, B., *Alexandra Tritschler et al. 2009, "27th ASI Meeting", IIA, Bangalore
Magnetic Structuring of an Emerging Flux Region

Srinivasan, R., Prabhu, T. P., Srinivasulu, G., Dhananjay, K., Pavan Kumar Sarma, Y., Jagadish Kumar, Sasitharan, T., Somashekar, M. R., & Janakiram, P., (Instrumentation team)
Bagare, S. P., Rajendra B. Singh, Namgyal Doorjey, & Thupstan Dorjey (Observations & scientific data analysis team)
J. P. A Samson, Dorjai Tsewang, and Angchuk Dorje (Tower design, construction & erection team) 2009, "27th ASI Meeting", IIA, Bangalore
Micro thermal measurements and data reduction device, 2009 for Site-Characterization related to NLST program

Stalin, C. S., Devendra Kumar Sahu, P Ravindra 2009, "27th ASI Meeting", IIA, Bangalore
Reverberation mapping of the AGN SDSS J0047+147

Subramanian, K. R., Ebenezer, E., *Raveesha, K. H. 2009 2009, "27th ASI Meeting", IIA, Bangalore
A statistical study of associated and non associated type II solar radio bursts

Sujatha, N. V., Jayant Murthy, *Henry, R. C. 2009, "27th ASI Meeting", IIA, Bangalore
Study of Diffuse Near and Far UV radiation using GALEX Deep Imaging Surveys

Sushma Mallik, *Maheswar Gopinathan 2009, "27th ASI Meeting", IIA, Bangalore
Estimates of stellar parameters in galactic open clusters via multi-wavelength photometry

Sutaria, F., *Paar, N., *Ring, P. 2009, "27th ASI Meeting", IIA, Bangalore
Weak interaction rates for nuclei of astrophysical interest from QRPA-RHB considerations

Sutaria, F. 2009, "27th ASI Meeting", IIA, Bangalore
Phase resolved spectroscopy of AXP J1708-4009

Sundara Rajan, M. S., Srinivasan, R., Somashekhar Bagare, Pavan Kumar Sarma, Samson, J. P. A. 2009, "27th ASI Meeting", IIA, Bangalore
Measurement of Fried parameter at various heights above ground a new approach developed for NLST

*Tejomoortula, U. S., *Choudhary, D. P., Rangarajan, K. E., *Na Deng, *Penn, M. J. 2008, "AGU SFO conference", December 14 – 19, 2008
Formation of Chromospheric Infrared Emission Lines of Helium and Hydrogen

Uday Kumar Gurugubelli, Anupama, G. C., Sahu, D. K. 2009, "27th ASI Meeting", IIA, Bangalore
SN 2005kd: Another Type IIn supernova with an unusual plateau

*Usha Sree Tejomoortula, Rangarajan Komandur, *Debi Prasad Choudhary *Na Deng, *Matthew J Penn 2009, "27th ASI Meeting", IIA, Bangalore
Formation of chromospheric absorption lines of Helium and Hydrogen

Vagiswari Alladi, Kameswara Rao N., Priya Thakur, Christina Birdie 2009, "27th ASI Meeting", IIA, Bangalore
Michael Topping and the Origins of the Madras Observatory

Veeresh Singh 2008, in Conf."Low Frequency Radio Universe," NCRA, Pune, December 8 – 12, 2008
Low Frequency Radio Universe Seyfert Galaxies

Veeresh Singh, Prajval Shastri, *Ramana Athreya 2009, "27th ASI Meeting", IIA, Bangalore
Radio Emission from Seyfert Galaxies

Velonganni Chinnappan, Saxena, A. K. 2009, "27th ASI Meeting", IIA, Bangalore
Tentative solutions for high-speed computations and control in AO experiments

Vyas A., Roopashree, M. B., Ravinder Banyal, Raghavendra Prasad, B. 2009, "27th ASI Meeting", IIA, Bangalore
Correlation studies of Kolmogorov screen

Vyas A., Roopashree, M. B., Ravinder Banyal, Raghavendra Prasad, B. 2009, "27th ASI Meeting", IIA, Bangalore
Comparison of different wave-front reconstruction and centroiding algorithms

Yerra Bharat Kumar, Bacham Eswar Reddy, 2009 "27th ASI Meeting", IIA, Bangalore
Detailed analysis of new Li-rich giants

IAU Circulars, Technical Reports etc.

Chakraborti, S., Prabhu, T. P., Anupama, G. C., *Kaur, A., Gurugubelli, U. K., *Ray, A. 2008, CBET 1638, 1
Supernova SN 2008 in M61

Gurugubelli, U. K., Anupama, G. C., Sahu, D. K., *Kaur, A. 2009, CBET 1687, 1
Supernova 2009P in Pgc 34730

*Ojha, D. K., *Ghose, S. K., *Kaurav, S. S., Bhatt, B. C., Sahu, D. K. 2008, IAUC, 9006
V1647 Orionis

Sahu, D. K., Anupama, G. C., *Misra, K. 2008, GCN 7700, 1
GRB 080506:Optical observations from HCT

Chapter 2

Facilities

2.1 Photonics Laboratory

VHRR sun shield panels for INSAT 3D satellites

As per the MoU, the polishing of six sets of sun-shield panels for INSAT 3D imager and sounder coolers along with the samples were completed. There is a request for polishing an additional set for the flight model and the modalities are being prepared to take up the work.

Long trace profilometer

The Long Trace Profilometer (LTP), version II has been delivered to RRCAT, Indore and the project has been completed.

Vacuum coating

Periodic maintenance works were carried out at the 1.5 m and 2.8 m vacuum coating plants at VBO, Kavalur.

The 1.5m coating plant has been upgraded. A new firing configuration has been implemented along with thickness monitoring unit. The entire coating process is now computer controlled using the Supervisory Control And Data Acquisition (SCADA) software.

Thin film research

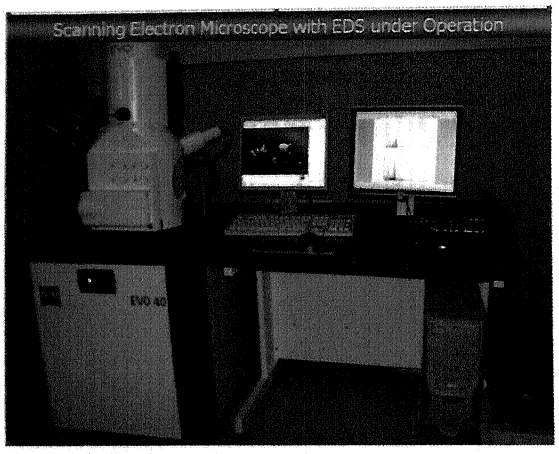
The BC 300 coating plant, the Scanning Electron Microscope (SEM) and Energy Dispersion Spectrometer (EDS) facilities have been in use for various training programmes of the institute. The BC 300 coating plant has been in continuous use for providing various multi-layer coatings like aluminium, silicon, silicon-dioxide, chromium, magnesium fluoride on glass substrates through electron beam (EB) gun facility. The sputtering unit was used for sputtering metal targets like copper, silicon, indium tin oxide, silicon nitride, magnesium oxide and aluminium on glass substrates. The Scanning Electron Microscope (SEM) and Energy Dispersion Spectrometer (EDS), have been used for characterizing quantitatively these thin film coatings.

10.5 micron detector development

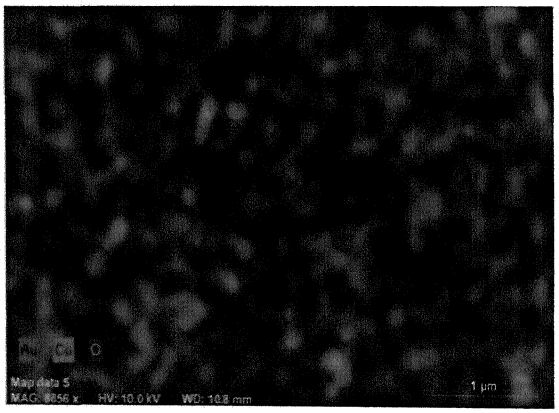
The design of the 10.5 micron detector has been completed and reported earlier. The design consists of multilayer coatings, which is carried out by the Molecular Beam Epitaxy (MBE) method. Such a facility does not exist in the institute. The Cavendish Laboratory, UK has agreed to grow that wafer for our purpose. The wafer has to be processed and characterized.

Development of gas sensor

As part of the training programme of the institute, the development of a gas sensor for detection of hazardous gases using thin film technology has been taken up. It was planned to study electrical characteristics and capacitance of the multi-layer coatings in the presence of gas mixture. As an initial step a study of copper gold alloy thin film on glass substrate was done. SEM and EDS instruments are shown in the photo below. The mapping done with EDS showing the distribution of Au, Cu O along the scanned area of the sample is also shown. Modifications are being made at the hydrogen furnace at VBO, to carry out the gas sensing experiment. The gas sensor test set-up is also shown. Gas mixtures have been procured and other preparations are being done for the study of sensor development.



SEM and EDS instrument.

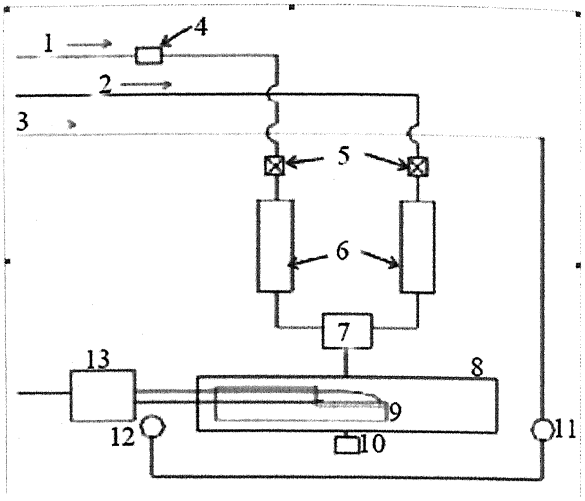


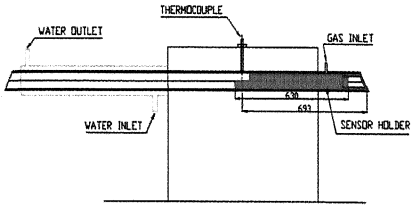
Mapping done with the EDS instrument.

Adaptive optics

An adaptive optics laboratory is being established at the Photonics Division, in order to undertake research programmes on adaptive optics. The initial focus is on developing an efficient wavefront sensing device. Experiments were conducted using Shack Hartmann wavefront sensor and shearing interferometer wavefront sensor. Faster speed is achieved by implementing efficient way of data handling in terms of data acquisition and centroid determination and optimizing the algorithms for both the wavefront sensors. Efforts are on to demonstrate a closed loop AO system in the laboratory.

(Photonics Division)





Gas sensor test set-up.

2.2 MGK Menon Laboratory for Space Sciences

Prof. MGK Menon Laboratory for Space Sciences is completely operational and is being used. This facility consists of clean laboratories in compliance with FED209E, MIL STD 1246C, ISO 14644-1 and ISO 14644-2 standards to meet VUV cleanliness requirements. It is a totally automated center with 24/365 monitoring facility to meet the above mentioned ISO standards. Primary purpose of this facility is to test, integrate and calibrate components and instruments for space-based observational platforms and is first of its kind in sophistication and utility in an any academic institution in India. There has been a constant effort to equip the facility to meet stringent demands of payloads such as UVIT, Space Coronagraph etc. The facility has been further augmented with Dry Nitrogen Generator, Dehumidifier, Vacuum Sealing machine, ultrasonic cleaner and thermovac chamber. This is in addition to existing large vacuum chamber, Zygo interferometer, reflectometer etc. Engineering Model of UVIT detector has been tested and cali-

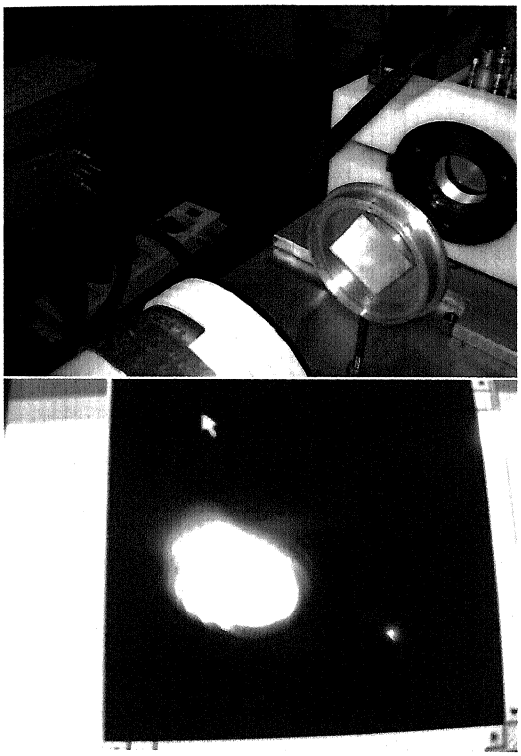
brated. Efforts are on to build engineering model of UVIT.

(B. Raghavendra Prasad)

2.3 Kodaikanal Observatory

The Solar Tunnel Telescope: Fabry-Perot etalon ET50 testing

The testing was performed for the Fabry-Perot etalon ET50 and CS100 controller, procured from Queensgate instruments, at the Solar Tunnel telescope. In the experimental set-up a mercury spectral lamp is used as a source and a 1k X 1k CCD camera as the detector. The control code for plate spacing and plate parallelism has been developed in C. The fringe pattern obtained is shown in the figures.



Experimental set-up and the observed fringe pattern.

(K. C.Thulasidharen)

Upgradation of 24 inch Solar Tower Tunnel Telescope

As a part of the upgradation of the 24 inch Solar Tower Tunnel Telescope, the entire control system and operations of the telescope, were fully replaced with a modernized system, introducing fine speed operations and the autoguiding mode, using superior electric SS 2000 drive and HS-50. All the handset operation cables have been concealed and plug-in socket terminals provided at the spectrograph, so as to eliminate the criss-crossing of the cables on the floor.

Modified solar power control panels and interior view of renovated Solar Tunnel Telescope.

Electrical systems of the entire telescope building have been replaced with modernized power panels, utilities, wirings, MK channels and lighting fixtures. The old numeric single phase UPS is now connected to all the single phase power utility points at the observation chamber, digitizer room and to the grating room. New 'power one' 3 phase-out UPS was installed and connected to the Siemens telescope tracking drive. Tracking was set to the required rate of 1417.51 rpm. The telescope was released for carrying out observations from December 2008.

(N. Sivaraj & Jagdev Singh)

Sky conditions : Kodaikanal Observatory

Number of observed days and seeing conditions.

		No. of observed days			Seeing conditions				
Year	Month	PHGM	WL	Ca K	5	4	3	2	1
2008	April	26	29	28	-	12	7	7	3
	May	24	27	27	-	11	14	1	-
	June	13	18	17	-	10	4	4	-
	July	15	16	16	-	10	5	-	-
	Aug	7	13	12	-	4	6	2	-
	Sep	19	19	20	-	7	10	2	-
	Oct	13	10	8	-	5	8	-	-
	Nov	13	16	16	-	11	5	-	-
	Dec	18	18	18	-	15	2	1	-
2009	Jan	26	29	26	-	19	8	2	-
	Feb	27	27	26	-	12	14	1	-
	Mar	24	26	23	-	7	14	5	-
		225	248	237	-	123	97	25	3

PHGM : Photoheliograms taken by film
WL : Whitelight filtergrams taken by twin telescope.
CaK : CaK filtergrams taken by twin telescope.
Seeing conditions (1-very poor, 2-very thick, 3-thick, 4-thin blue, 5-excellent)

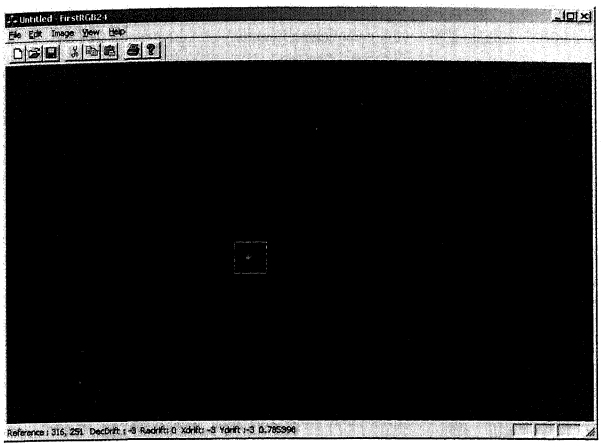
Solar Tower Tunnel telescope from April 2008 – March 2009.

Month & year	Seeing in arcsec				
	3	3 to 4	4	4 to 5	poor
April 2008	9	3	4	–	3
MAY 2008	7	5	1	2	1
June 2008	3	–	6	–	–
July 2008	–	–	–	–	–
August 2008	–	–	–	–	–
September 2008	–	–	–	–	–
October 2008	–	–	–	–	–
November 2008	–	–	–	–	–
December 2008	11	–	6	–	2
January 2009	15	2	1	–	2
February 2009	11	–	5	–	–
March 2009	8	4	5	–	5

From 25-06-2008 to 31-11-2008 telescope was under maintenance.

2.4 Vainu Bappu Observatory, Kavalur

Autoguider for echelle spectrograph



Screenshot of the autoguider programme.

An autoguider is installed for the fiber- fed Echelle spectrograph at VBT (see figure). It is a PC based application, which uses a frame grabber card to capture frames from the guide camera. The star position in the frame and its drift from the fiber are determined and the required correction is done by operating the appropriate relays of the telescope through the printer port in the PC using a driver interface unit. The guide camera is ISIS3 intensified CCD camera from Photonic Science Ltd. The camera output is CCIR video standard, producing 25 frames (interlaced) per second. The camera images the sky and the fiber. The star, when centered on the fiber, would still be visible due to the reflection from the fiber tip. The 100 micron fiber along its sheath occupies nearly 10 arcsec field at the prime focus. The frame grabber card is Picolo 32 bit PCI bus image acquisition card from Euresys. The software is written in visual C++ 6.0 under windows 2000 platform.

The fiber position is manually marked on the screen and the star is positioned at this reference point. Once the autoguiding is initiated, the reference position is quickly determined. A region of interest 40 x 40 pixels centered on this reference pixel is chosen for processing subsequent frames. The centroid of the star and its drift from the reference position is deduced for every cycle. If the drift is more than two pixels, a flag is set for that axis and the guiding is started. It is continued for subsequent cycles till the drift is zero for that axis. The relay on time is proportional to the drift. The guide speed used is the one arcsec per second option available at VBT. The system also creates a log of the axes drift and time for every cycle. The autoguider could maintain an accuracy of +/-0.75 arcsec for nearly 97 % of a 45 minutes exposure period.

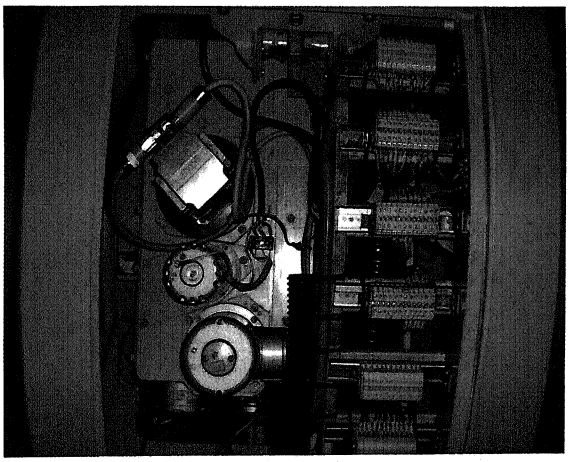
For fainter objects the discrimination between the noisy speckles and the signal is done by applying a 5 x 5 median filter and adding five frames. The time taken for each cycle is about 200 milliseconds. A 10.2 magnitude star was guided yielding a S/N ratio of 60 with this method. Further refinements to reach fainter objects are in progress.

(P. Anbhazhagan & K. Ravi)

1m Zeiss Telescope

Modernized R.A. tracking drive system for 1m telescope

The R. A. tracking drive system for the 102 cm telescope is being upgraded using the recent version of advanced tracking drive system and motor. The MC drive developed by Siemens with built-in incremental encoder was found suitable.



View of new tracking drive motor mounted on the R.A axis.

The system was installed and commissioned successfully at 102 cm telescope at VBO, Kavalur in April 2008. Power cable, signal cable, and communication cable have been laid from the control rack at the control room to the telescope. Testing and trial runs were conducted with the telescope pointing in various positions, for checking the stability, pointing accuracy and the present performance is as follows.

The image stands in the centre of the crosswire for more than 30 minutes when the telescope is pointing East. Westside there is a drift of about 27 pixels in 22 m. 62.4 arcsec on a continuous auto save mode. From Zenith towards west the drift is about (3 mm) 46.8 arcsec in 24 m, northeast the drift is 21.84 arcsec in 24 m, southwest the drift is 17.16 arcsec in 12 m. Balancing of the telescope may improve the performance. The above tests were carried out using 2K X 4K CCD, on continuous auto save mode.

(N. Sivaraj & R. Srinivasan)

Multichannel polarimeter

Development work is being done for the multichannel polarimeter for stellar observations. Testing of the main processor board, 3 sets of 24 bit PMT pulse counters and chopper controller boards are completed. Once the integration of all the boards inside the controller box is completed, motors will be tested in the instrument's optical path.

(G. Srinivasulu & K. Ravi)

4K X 4K mosaic camera

The camera system comprises of 2.4 L dewar which houses two buttable 2k X 4K CCD sensors (each 15 X 15 micron pixels) and a CCD controller. CCD controller unit has been built to accommodate the digital signal processing board, analog signal processing board and two numbers of bias and clock boards. Each CCD is driven by its own bias and clock board. A window based data acquisition software is used to configure the controller and acquire images from the camera. A pre-amplifier board is made with two channels loaded for the two number of CCD chips. The pre-amplifier gain has been currently set at 2.5. ZIF socket wiring has been completed. A chip mounting base plate is made to accommodate the two CCDs. The gap between the edges of one CCD chip to another chip is 0.3 mm and the flatness of the mount surface is within 0.015 mm.

(R. Srinivasan, K. Anupama, M. R. Somashekar & K. Sagayanathan)

A CCD cryostat based on cryo coolers

An experimental CCD cryostat based on the cryo-cooling technology has been developed which does not use liquid nitrogen for obtaining cryogenic temperatures required for CCD sensor cooling.

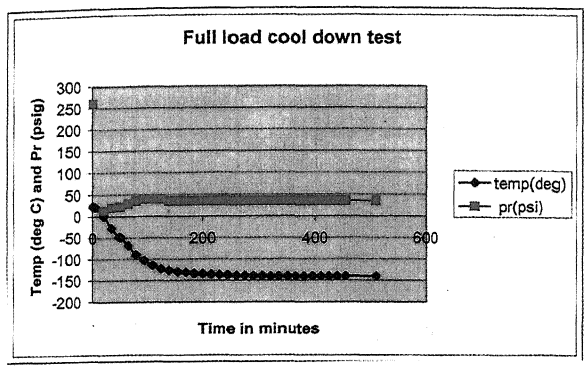
The cryostat or dewar integrates a commercially available cryo cooler called as cryotiger which delivers approximately 12 Watts of refrigeration at 94°K and is the main cooling unit. The necessary cold finger connections were designed to interface cryotiger cold head and the CCD base; also cryostat is appropriately designed to accommodate the cold head, cold finger and CCD sensor and some minimal electronics required for the operation of the CCD camera with requisite vacuum ports, electrical connectors and flanges for mounting of a quartz window which permits light to fall on the CCD sensor. The unit has undergone testing both in the lab and at field. Based on the cool down tests performed on the instrument, the lowest temperature recorded on the CCD base was found to be 142°C under full load condition which was achieved in about 3 hours. An aluminium flange forms a front plate. A quartz window of 90 mm dia and 3 mm thick on the mounting flange allows outside light to fall on the CCD sensor.

Cryotiger system comprises of a compressor, flexible gas lines (50 ft,) and the cold head. The cold head with the CCD base will be mounted on the cryostat which is pumped down to 1 X 10^6 torr.

The specification of the CCD cryostat is as under:
1. Requires only electrical power of 500 watts. Does not require liquid nitrogen for cooling the CCD sensor.
2. Attains a temperature of -120° C in about 3 hrs after cryotiger compressor is switched on.
3. Uses a flexible cold finger mechanism to ensure that the sensor is cooled to this temperature.
4. The cold finger mechanism introduces minimal thermal load and also reduces the vibration levels.
5. The cryotiger and the CCD sensor are integrated into a dewar which is to be evacuated to 1x10^6 milli bar pressure.
6. The dewar holds the vacuum approximately for about 4 weeks.

Test set-up : The CCD cryostat has been presently mounted with a TEK 2K X 2K CCD sensor along with a pre-amplifier board inside the dewar. The cryostat is connected to the compressor of th cryotiger after attaining a vacuum level of 1 X 10^{-6} torr. The entire cool down test which is a variation of gas pressure at the compressor end and the temperature at the CCD base is as indicated in the figure. This process of cooling takes approximately about 150 min from room temperature to about - 140° C. A maximum temperature of about - 140° C

is attained at a pressure level of about 30 psi at the compressor end of the cryo cooler.

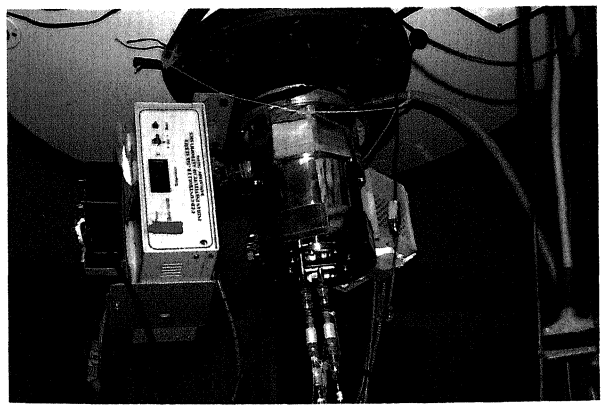


Full load cool down test.

(A. V. Ananth, S. Naghabushan, & N. Sagayanathan)

The CCD camera system based on cryotiger cooling was tested with 2k X 2k tek chip with the camera controller developed in-house.

The camera mounting arrangement at the back-end of the telescope is shown in the figure. An image acquired from the 40 inch optical telescope at the Vainu Bappu Observatory is shown in the figure.

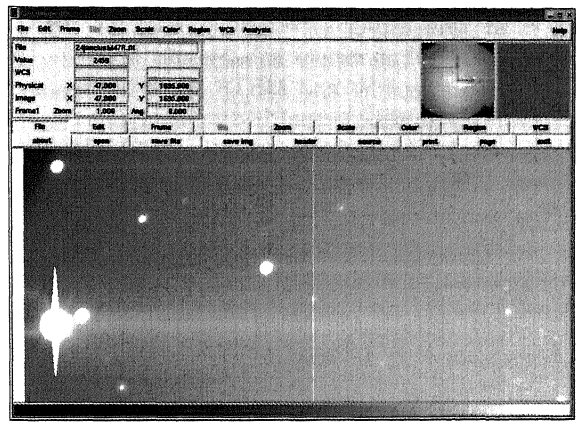


The Camera mounting arrangement at the back-end of the telescope.

(A. V. Ananth, V. Arumugam & K. Anupama)

2k X 4k CCD camera system for the 30-inch telescope

A CCD camera system based on 2k X 4k EEV sensor and using the cryo-cooling technology is under



An image acquired from the 40 inch optical telescope at the Vainu Bappu Observatory.

development. The cryostat has been modified to accommodate the ZIF socket and and the pre-amplifier board for the new sensor. The system is to be tested shortly on the 30 inch telescope at Kavalur.

The software for CCD camera controller and image acquisition were under linux environment using gtkmm as the grahics tool kit for image display and image manipulation. The software uses client/server concept and could be deployed in a LAN/WAN environment to remotely control the CCD camera operations.

(A. V. Ananth, V. Arumugam & K. Anupama)

Control software for 30-inch telescope

The control software for the newly refurbished 30 inch telescope is under testing. The software is intended to be developed in two phases: (a) The first phase implementation includes an autonomous mode where the telescope, dome and auto-guider work independently. (b) The second phase involves a networked mode, where the telescope, dome, auto-guider, with a common user interface communicate through a central communication server. This will also enable the back-end instruments to communicate with other sub-systems.

Presently the telescope control software with interactive commands is ready and is being tested at Kavalur.

(A. V. Ananth, P. Anbazhagan & K. Ravi)

As part of phase II development, a prototype version of the communication server is currently available for testing. Developed under linux, this uses

client/server and server/server communication for distributed control of various sub-systems like telescope/dome, autoguider and METS. Each of these instruments operate as virtual instruments and the communication is basically between these virtual instruments. The client/server uses TCP/IP with POSIX socket communication and could be used in LAN or WAN environment. The scheme is somewhat similar to what is available for 2 m telescope at Hanle.

(V. Arumugam & A. V. Ananth)

Dome control software

A dome control software for auto-dome movements is under development. The programme is under windows-NT. The software is to be tested shortly. The dome movements are from AC synchronous motor controlled by a SIEMENS micro master-420 invertor. The shutter movements are from D.C. Motors initiated remotely by radio controls.

(Faseehana Saleem & A. V. Ananth)

An incremental test unit for 30-inch telescope

A test unit for testing the incremental encoder unit used in the 30 inch telescope has been developed, with a view to obtain: (a) position information (degrees or counts) with reference to a homing switch position or alternatively with reference to an index pulse position; (b) counts/sec (tracking); (c) rpm; (d) fault information indication.

The signals forming the incremental encoders are received by a quadrature clock converter chip LS 7184 from a teledyne gurley-8560 encoder unit. Cascaded 74LS190 decade counters count the encoder pulses and display the position using 7 segment LEDs. The encoder resolution is 0.0001 degree or 0.36 arcsec.

The RPM information is obtained by counting the index pulses from the encoder. The choice of the mode is selected by front panel switches. This unit is useful for the stand alone tests of the incremental encoder which generates differential quadrature output signals.

(K. C. Thulasidharen, C. V. Sri Harsha, M. R. Somashekar & A. V. Ananth)

Sky Conditions : Vainu Bappu Observatory, Kavalur

Month	Spectroscopic Hours	Photometric Hours
April 2008	173	47
May	48	00
June	37	03
July	19	05
August	20	03
September	68	04
October	81	26
November	93	30
December	179	81
January 2009	252	94
February	316	208
March	177	75
Total	1463	576

VBT Time allocation during period : 1 April 2008 – 31 March 2009

Total number of proposals received :	20
Number of photometric proposals :	2
Number of nights allotted :	10
Number of spectroscopic proposals :	18
Number of nights allotted :	324

2.5 Himalayan Chandra Telescope

Indian Astronomical Observatory, HCT

The 2-m Himalayan Chandra Telescope (HCT) continued to be utilized in the remote operation mode for the ninth year since its installation in the year 2000. Comprehensive preventive maintenance was carried out in November 2008 by the staff astronomers and engineers of HCT, together with two engineers from EOST, Tuscon. Astronomers utilised the telescope from Bangalore with the help of assistants from local villages at 4300 m altitude near Hanle and research trainees recruited for the purpose at CREST, Hosakote. The total research output of HCT in refereed journals reached nearly 70 papers.

The telescope operates fully on solar photovoltaic power. The batteries that store the power generated during the day for operating the telescope at night are nearly 10 year old, and have thus outlived their life expectancy by a factor of two. Efforts are being made to procure funds to replace them before they lose their life totally. Efforts are also being made to procure funds and human power required for the upgradation of the facility. Plans include upgradation of the secondary drive unit, development of Rayleigh scattering adaptive optics technology, development of second generation instrumentation, implementation of HCT data archive, and integration of software with the observatory server.

HCT obtained images of the moon in automatic tracking mode when Chandrayaan was passing over its face before releasing the Moon Impact Probe on 14 November 2008. There was no detection of any disturbance due to the impact.

HCT was selected for inclusion in the 24 hour webcast "Around the World in 80 Telescopes" as a part of IYA cornerstone project 100 hours of Astronomy, 2 – 4 April 2009. Webcast from HCT and its remote control station at CREST was scheduled between 00:10 - 00:30 IST on 4 April 2009.

(T. P. Prabhu)

HTAC

HCT time was allotted on competitive basis for the sixth year. Over 14 research papers were published during the year utilizing the HCT data bringing the publication rate to more than one paper per month. The total publications based on HCT data crossed 65.

A total of 36, 16, 24 and 21 proposals were received for HCT cycles 15, 16, 17 and 18 respectively spanning the time between 2008 January and 2009 April. Of these proposals, 11, 16, 22 and 20 proposals were allotted a total of 270 nights between 2008 April and 2009 March. About 4 – 6 nights around full moon were utilized for monthly calibrations of the telescopes, and additional 10 nights were used in August 2008 for annual preventive maintenance activity by IIA staff, and a similar time during November 2008 by a delayed visit of EOST maintenance staff.

(T. P. Prabhu)

Night sky at the Indian Astronomical Observatory, Hanle

A good astronomical site is characterized by various atmospheric parameters (transparency, seeing), meteorological parameters (wind, snowfall, surface temperature, rainfall etc. and sky brightness) and geographical conditions (local topography, seismicity, source availability). Sites having minimum cloud coverage, very low frequency of snowfall/rainfall, low relative humidity, low night time temperature variation,high atmospheric transparency and low night sky brightness are generally considered good for grounbased optical and IR astronomy. Night sky brightness and atmospheric extinction are the two main characteristics of the night sky. An analysis of the optical night sky brightness and extinction coefficient measurements in U,B, V,R and I filters at the Indian Astronomical Observatory, Hanle during the period 2000 – 2008 was carried out. It has been found that the zenith corrected values of the moonless night sky brightness in mag/arcsec^2 are 22.14 $\pm$ 0.32 (U-band), 22.42 $\pm$ 0.30 (B-band) 21.28 $\pm$ 0.20 (V-band), 20.54 $\pm$ 0.37 (R-band) and 18.86 $\pm$ 0.35 (I-band). Extinction values were also measured from analysis of 1325 images over 58 nights during the period 2000-2008. They are found to be 0.36 $\pm$ 0.07 (U-band), 0.21 $\pm$ 0.04 (B-band),0.12 $\pm$ 0.04 (V-band), 0.09 $\pm$ 0.04 (R-band) and 0.05 $\pm$ 0.03 (I-band). Details of this work can be found in BASI, 2008, 36, 111.

(C. S. Stalin, M. Hegde, D. K. Sahu, P. S. Parihar, G. C. Anupama, B. C. Bhatt & T. P. Prabhu)

Sky Conditions, Indian Astronomical Observatory, Hanle, Ladakh

Year	Month	Photometric (night hrs)	Spectroscopic (night hrs)	Total (night hrs)
2008	April	107	161	240
	May	63	110	217
	June	28	110	210
	July	90	105	217
	August	56	80	248
	September	138	156	270
	October	203	265	310
	November	271	297	330
	December	244	277	341
2009	January	120	174	341
	February	138	175	280
	March	125	159	341
	Total	1583	2069	3283

2.6 HAGAR telescope

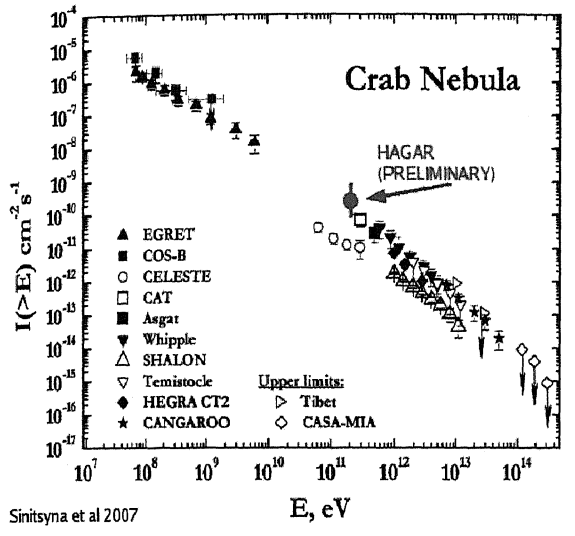
Observation in the interesting energy region (10–100 GeV) in gamma ray astronomy is possible by operation of Atmospheric Cherenkov telescopes at high altitudes. The effective Cherenkov photon density near the shower core at a high altitude site like Hanle is higher by a factor of about 4 – 5 compared to that at the sea-level. Therefore, for accessing this interesting energy region, the HIGRO collaboration (comprising members from TIFR, BARC and IIA) has started conducting Atmospheric Cherenkov experiments at Hanle (4300 m asl) in Himalayas. The gamma ray energy threshold will be brought down in two phases with reduction to just below 100 GeV in the first phase with a 7 telescope array called HAGAR and subsequent decrease in the second phase with a 21 m diameter telescope called MACE, both at Hanle in Ladakh.

The HAGAR (High Altitude GAmma Ray) array, which is the first phase, consists of 7 telescopes arranged in the form of a hexagon with a spacing of 50 m and one telescope at the center. Each telescope has seven para-axially mounted front coated mirrors of diameter 0.9 m with a UV sensitive phototube at the focus of each mirror. These telescopes employ an alt-azimuth mount. The telescope pointing accuracy after incorporation of a pointing model is 1.25 arcmin. However, each telescope has 7 independent mirrors in each telescope. Therefore, the co-alignment of these mirrors is an important issue to be addressed in-addition to the pointing of the telescope as a whole. Several steps are involved in the improvement of telescope pointing viz. a scan in RA-DEC space around a bright star to measure the pointing offsets of the mirrors, mechanical adjustments of mirrors for the pointing offsets if any and use of analytical pointing model for the tracking and orientation of the telescopes. The co-alignment of mirrors was improved through few iterations of fresh RA-DEC scans of bright stars and mirror adjustments. The overall pointing accuracy of HAGAR telescope mirrors achieved so far is $0.20\pm0.12°$. Further efforts are being made to reduce this value by modifying the mirror holding system.

The Data Acquisition (DAQ) system was upgraded by adding a parallel DAQ system using commercial ACQIRIS make digitizer to digitize and record fast pulses for each event. The ACQIRIS system continuously digitizes all the eight analog channels and records data in the range of pre and post samples to a valid trigger. It also records time stamp of each trigger using GPS clock. This system is independent to the existing CAMAC based conventional DAQ system built in-house. The data from these two systems are collated offline.

From the analysis of the engineering runs, it was found that the best mean angular resolution in the estimation of arrival direction of the shower is about $0.23\pm0.09°$. The highest trigger rate was about ≈ 14 Hz for the vertical direction. Simulations show that this corresponds to a threshold energy of 185 GeV. Regular observations were started in September 2008 on several sources including Crab Nebula and pulsar, Geminga pulsar, AGNs (1ES 2344+514 & Mkn 421).

Monte Carlo simulations for HAGAR were updated taking into account results from test runs.



Preliminary result on the gamma rays from Crab Nebula from HAGAR experiment ; the number of gamma rays is 7.0 ± 0.9 per minute with the significance of the detection at 9 sigma.

Large sample of extensive air showers initiated by gamma rays, protons, alpha particles and electrons were simulated using CORSIKA package. Cherenkov photon distribution obtained from CORSIKA is passed through detector simulation programme developed in-house. Detector parameters in the programme are tuned according to the present experimental set-up. These simulations could reproduce the observed trigger rate of about 14 Hz. For this trigger rate, the expected flux from Crab Nebula is about 9.6 gamma-rays/min. Efforts are underway to decrease the energy threshold further which would be possible with better alignment of mirrors and other improvements. The energy threshold could be lowered to about 100 GeV by operating photo-tubes at slightly higher gain than that at present.

The HAGAR data were analyzed by fitting a plane front to the relative arrival time of pulses. The space angle between the direction of telescope axis and the fitted direction was estimated. Based on 10.7 hours of data from the Crab Nebula a preliminary result of 7.0 ± 0.9 gamma rays/min for the flux of gamma-rays, is reported. The energy threshold of gamma-rays for this analysis is about 200 GeV. The significance of the signal is ≈ 9 sigma. The figure shows the HAGAR point along with those from other experiments. It can be seen that the flux agrees with the expected flux from a fit to other experiments.

This is a collaboration between IIA and TIFR.

(HAGAR team)

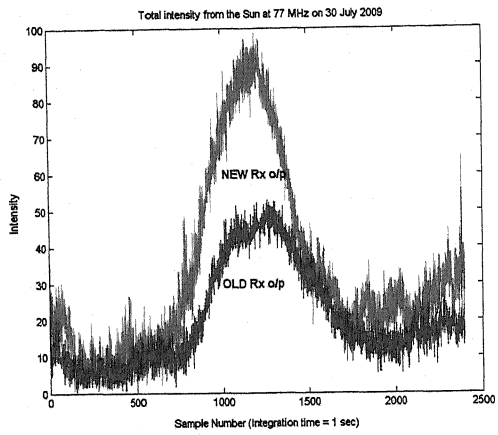
2.7 Gauribidanur Radio Observatory

Gauribidanur radioheliograph (GRH) expansion

The existing GRH array and its receiver system are being modified since the middle of 2008 to probe the solar corona with higher angular resolution and better sensitivity. In its new configuration, the GRH will have a maximum baseline length of about 3 km, yielding an angular resolution of about 2 arcmin at 150 MHz. For comparison, the upcoming Murchinson Widefield Array (MWA) in Australia will have a resolution of about 4 arcmin at the same frequency. While the MWA is expected to observe over the band 80-300 MHz, the GRH observations are over 30 - 150 MHz. And no other radio telescopes for dedicated observations of the solar corona are in operation in this low frequency range close to the limit of radio observations from the ground. The GPS survey of the new antenna locations, leasing of the land required and mounting of the support structures on which the new antennas will be erected are all completed as of January 2009. The fabrication of all the 192 antennas required for the expansion was completed in-house at Gauribidanur during June 2009. On the receiver side, the fabrication of the analog front-end receiver is going on in-house at Gauribidanur. The 4096-channel backend digital receiver system to correlate the signal from the 64-antenna groups in the expanded array is being developed at the electronics division of our Bangalore office. The prototype analog and digital receiver system unit was tested for large bandwidth observations (so as to get better sensitivity). The results are shown in the figure given below. There is a considerable enhancement in the signal-to-noise with the new system. It is expected to carry out regular observations with the expanded array in early 2009. See figure.

(Radio astronomy group)

The radio heliograph at Gauribidanur will have a length of 2 kms in EW direction and 1.5 km in NS direction, after expansion. About 200 LPD elements will be used to receive the signals from astronomical sources. It is also planned to increase the LF BW from the present 1 MHz to 3 MHz. A prototype correlator system, sampling lF signals at 12 MHz and introducing delay to the extent of 14 msec was successfully installed and tested at Gauribidanur. The design used to build the prototype system, will be



The above figure shows the scan of the total intensity from the Sun at 77 MHz on 30 July 2009, as it drifted across the antenna response pattern. The red profile is the output observed with the existing receiver system with 1 MHz bandwidth. The red profile is the output with the prototype new receiver system (4 MHz bandwidth) designed for the GRH expansion programme.

used to process the signals from 200 LPD elements of the expanded radioheliograph and also to process the signals from 32 antennas in the second phase of the Brazilian Decimetric Array.

(M. S. Sundararajan)

2.8 The Library

The library continues to provide high quality scholarly information to the faculty and students promptly.

Enhancing the library collection: The library collection has been enhanced with additional titles acquired for the newly initiated Integrated Ph D & Integrated M. Tech-Ph D (Tech. Programme). The collection requirements of libraries at all field stations have been met. Few titles of reference books are added in both print and electronic format. Library has cataloged and classified all these books using libsys software, and amalgamated these into the main database.

Providing additional electronic resources: The library was able to extend the range and depth of the collection through the CSIR-DST Consortium which was launched recently. The following database of journals from different publishers are available online from IIA campuses at Bangalore, CREST at Hosakote, Vainu Bappu Observatory at Kavalur, Solar Observatory at Kodaikanal and Indian Astronomical Observatory at Leh and Hanle, in addition to the already existing astronomy journals.

American Chemical Society; American Institute of Physics (AIP); The American Physical Society (APS); Emerald; IEEE/IEE Electronic Library Online (IEL Online): IEEE Xplore; IOP Science; J-Gate Custom Content for Consortia; Nature; OSA Journals; Springer; Taylor and Francis (Physics and Astronomy); Web of Science

The Library offers inter-library loan service to its scientific community for research resources not available in the IIA Library, through stronger links with the other astronomy libraries within and outside the country. Library, in turn, also lends its resources to FORSA libraries on reciprocal basis. 198 Interlibrary loan requests from scientific and technical staff were fulfilled during the period April 2008 – March 2009. Additional journals for display are brought from the library at RRI regularly.

The following new Indian journals have been added to the existing collection during the year, Indian Journal of Traditional Knowledge, Bharatiya Vaigyanik Evam Audyogik Anusandhon Patrika (in Hindi) and Puratattva - Bulletin of the Indian Archaeological Society.

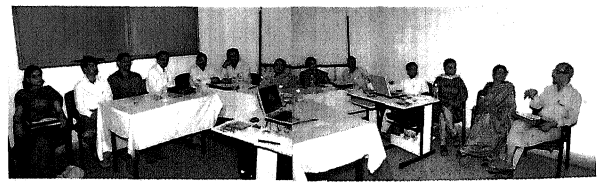
The Library offers photocopying service to its members. Recently Canon photocopier cum network printer has been installed in the library & the individual accounts have been created for the users to operate the machine.

The library assisted in the delivery of bibliometric and scientometric analysis of IIA publications required for making policy decisions.

Institutional Repository : IIA Open Access Repository continues to grow steadily with more and more contents added with old and current research publications. The repository has been listed in the "First 300 repositories in the world", a list compiled by Cybermetrics Lab CSIC, Spain.

Insurance : The process of insuring the library materials which include books, journals, furniture, fittings & electronic equipments on a regular basis, has been initiated.

FORSA Meet during 27th ASI Conference: The



Prof. Ram Sagar addressing the Forsa members.

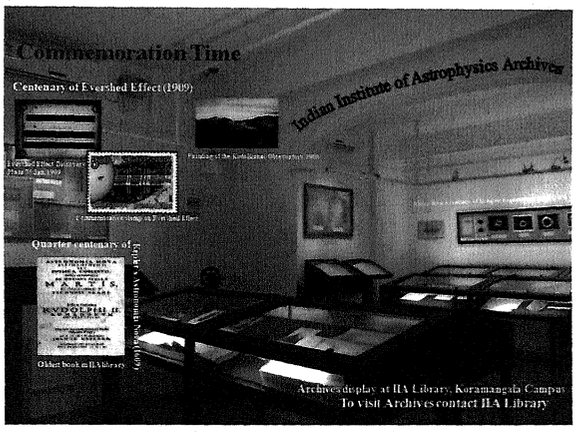
members of FORSA (Forum for Resource Sharing in Astronomy) held a meeting during the 27th ASI Meeting, held at IIA Bangalore on 19 – 20 February, 2009 as in the photo. There were representatives from IIA, RRI, TIFR, IUCAA, NCRA and ARIES libraries who came together to discuss new initiatives in their libraries. The digitization projects and the facilitation of open access repositories of the institutes were a few important initiatives in all the libraries. The members also discussed issues pertaining to various license agreements, signed by the librarians to access e-contents. The librarians expressed the need for legal support from the management in interpreting the technical legal clauses before signing the license agreements.

Prof. Ram Sagar, Director, ARIES, shared his views and expectations from libraries, as a user and emphasized the need for proper planning for collection development and training of human resources for setting up a state-of-the-art library. On the second day the FORSA librarians discussed the various arrangements and requirements for the forthcoming International conference LISA VI (Library and Information services in Astronomy) to be held at IUCAA, Pune in February 2010, organized by FORSA and co-hosted by IUCAA and NCRA libraries together. The various issues discussed and deliberated among FORSA members were put forward during the joint session of astronomers and librarians on the last day of the ASI conference.

Archives and the Evershed Effect centenary conference : To commemorate the centenary of the discovery of the Evershed Effect, an international conference was organized at IIA on December 2 – 5, 2008. Library rendered full support to this conference by providing the essential historical information on Evershed Effect from the Archives. This information was used in preparing the Centenary Brochure, Invited talks and to prepare the Evershed Effect first day cover and stamp as in the photos.

The Archives has also displayed the original plate with recordings of sunspot spectra, which is know as Evershed Effect, discovered on January 5, 1909, at Kodaikanal Observatory by John Evershed. IIA Library contributes research articles and news from the archives to the IIA Newsletters regularly. IIA Library has been enrolled as a member in the Society of American Archivists.

(Librarian)



The Indian Institute of Astrophysics Archives.

2.9 Computational and IT Facilities

The computer facilities at IIA are designed around an individual model where every scientist has their own computer with central facilities intended for support. As such, there are over 200 computers in the Institute, almost all are PCs. These are tied together by a CAT-6 (1 Gbps) backbone and wireless. The link to the outside internet is through an 8 Mbps connection allowing immediate access to databases around the world.

A centralized Computer Centre hosts a number of single user machines where short term visitors and students work. This Centre also hosts a 10 TB disk server which is used for storage for the large amounts of data which will soon come from IIA's space and ground-based observatories. Eight and 16 node clusters are heavily used for the needs of several groups who require access to large amounts of CPU time.

Field stations are all being upgraded to at least 2 Mbps links with a 5 Mbps link at the CREST campus. Plans are underway to link all campuses together to form a virtual campus.

(Computer division)

2.10 Infrastructure

Bhaskara Hostel & Guest House

IIA now has new well-equipped accommodation for students and visitors. Inaugurating Bhaskara, IIA's new hostel and guest house, on the 16th November, 2008, the Secretary of the Department of Science and

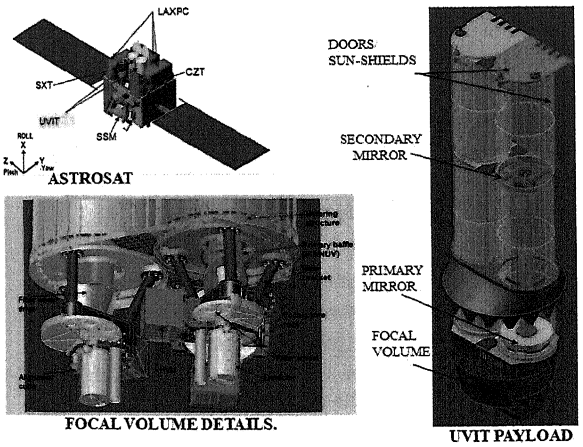
Bhaskara hostel and guest house.

Technology, Dr T Ramasami, underlined the importance of good facilities for young people taking up research careers. Bhaskara is located a short distance away from IIA's main campus, on the same street. It is a multi-storeyed building as seen in the picture, with 45 rooms to house students, post-doctoral fellows and visitors to IIA. It is equipped with a modern kitchen, a spacious dining hall and internet connectivity. K Jaisim, the renowned architect of Bangalore, designed the building.

2.11 Upcoming Facilities

2.11.1 UVIT on ASTROSAT

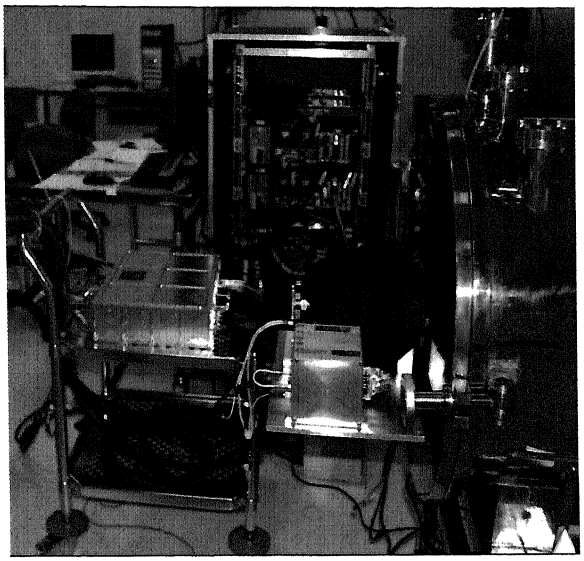
UVIT is one of the five science payloads on ASTROSAT: there are four X-ray telescopes, which observe in the soft/hard X-rays, and UVIT observes in the ultraviolet and the visible bands. Three of the X-ray telescopes and UVIT can observe an object simultaneously. UVIT observes simultaneously in Far-UV (1300 – 1800 Å), Near-UV (1800 – 3000Å), and VIS(3500 – 5500 Å); UVIT makes images with an angular resolution of 1.8 arcsec in a field of 29 arcmin; in addition to a selection of filters for each of the three channels, low resolution (100) slitless spectroscopy is available for Far-UV and Near-UV channels. ASTROSAT aims to observe simultaneously in X-rays, UV and visible. UVIT will be used to study the time variability of X-ray objects, on timescales ranging from seconds to days, in coordination with the X-ray telescopes, and would observe on its own objects like interacting galaxies, star forming galaxies, globular clusters, hot/evolved stars. The figure shows the UVIT configuration with all subsystems.



The UVIT configuration.

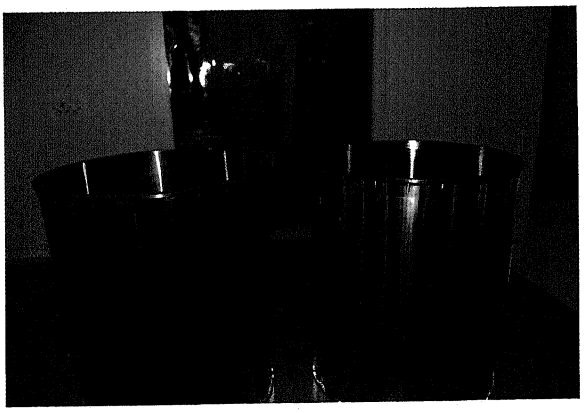
Present Status: The engineering model detector has been completed and qualified, and delivered to IIA by the Canadian Space Agency who is a collaborator with the UVIT project. The detector has been tested with the ultraviolet optical test systems at MGKM Laboratory, CREST, IIA, as in the figure. The flight model detectors are under fabrication in Canada, and are expected to be delivered to IIA before end of year 2009.

Fabrication of the flight model mirrors has been completed by Linear Electro Optical Systems (LEOS, ISRO), and are undergoing various tests. LEOS has also developed reflective coating for the mirrors with a reflectivity > 70% in the far ultraviolet; this coating shall be applied to the mirrors after these have been fully tested.



Testing of the EM detector in MGKM Laboratory is shown. The electronics unit for the detector is seen on the left, on the trolly, and the camera proximity unit (opto-electronic part), covered by a black mask, is mounted on the vacuum chamber on the right. The high voltage unit is seen on a plate next to the CPU. The ground support equipment is seen on the back.

Analysis of the structure has been completed to satisfy the requirements of vibration tests. Thermal control too has been analysed to show that temperature of the telescope tubes will be controlled within 2 C so that change in focal position is not beyond acceptable limits.



Telescope tubes in the MGK Menon Lab.

The fabrication of the three invar telescope tubes

and the two main baffles, which are the main parts of the UVIT mechanical structure, are completed. The fabrication of back focal components are under progress. Tha figure shows the finished invar telescope tubes in MGK Menon lab, Hosakote.

The structure is under fabrication, and the engineering Model is expected to be assembled by the end of year 2009. The flight model is expected to be ready by middle of year 2010.

(UVIT team)

2.11.2 TAUVEX

With the launch date of the Indo-Israeli collaborative project TAUVEX (Tel Aviv University UV Explorer) fixed for October this year, the astronomical community will have access to a flexible instrument for observations in the mid-UV range 135 – 400 nm. The instrument was calibrated in Israel and has been delivered to ISRO earlier this year. TAUVEX will be integrated with the GSAT-4 satellite early September and shipped to the launch site at the end of September.

The TAUVEX Core Group at IIA, responsible for the scientific planning of the mission, development of the pipeline and science tools, is getting ready for the launch with the completion of the plan for the first few months of the flight—Performance Verification (PV) phase, development of the calibration procedures with the full list of calibration targets, and the development of a data centre for access to TAUVEX data. The TAUVEX pipeline is now complete and will produce useable images and point source catalogs from the raw spacecraft data, and is now being integrated with the data archive. One of the innovative aspects of the TAUVEX data flow is the planned access to real-time data at the TAUVEX data centre through a direct link with the Master Control Facility in Hasan.

Scientific activities over the last year included several TAUVEX-related publications in various journals and proceedings, participation in ASI2009 Meeting presenting various aspects of TAUVEX calibration plan, TAUVEX-related talks at several institutions in India and abroad.

The main task now in progress is updating the essential mission documents on the TAUVEX Webpage, such as *TAUVEX Observers Manual* and *Pre-Launch Call for Proposals*. The full calibration plan will be documented in *TAUVEX Calibration Techniques and Procedures* and published online.

(TAUVEX team)

2.11.3 The 1.3m Telescope at VBO

Since installation in 1970, the 1 metre Zeiss telescope had been the workhorse of the Vainu Bappu Observatory and it would not be wrong to say that all the observational astronomers at IIA and a large fraction of those in other Indian institutions have gained observing experience from this telescope. The telescope is a vintage design of the 1960s or earlier, an era where photographic plates and films were the detectors available to astronomers. Further, since the early 1990s patches of reduced sensitivity have been seen on the primary mirror and these have increased after each re-aluminisation.

The 2.3 metre Vainu Bappu Telescope was designed and built by the Institute during the years 1978 – 84. Being the first attempt to build a 'large' (by the prevailing standards) optical telescope indigenously, the VBT is based on conservative designs of the era. As a result it is perhaps over-designed, and the mechanical structure and large building and dome result in the somewhat poor seeing induced by thermal effects. Consequently there has been a shift in the usage of the VBT to spectroscopic observations. The Himalayan Chandra Telescope is the choice for most imaging observations of northern sky objects.

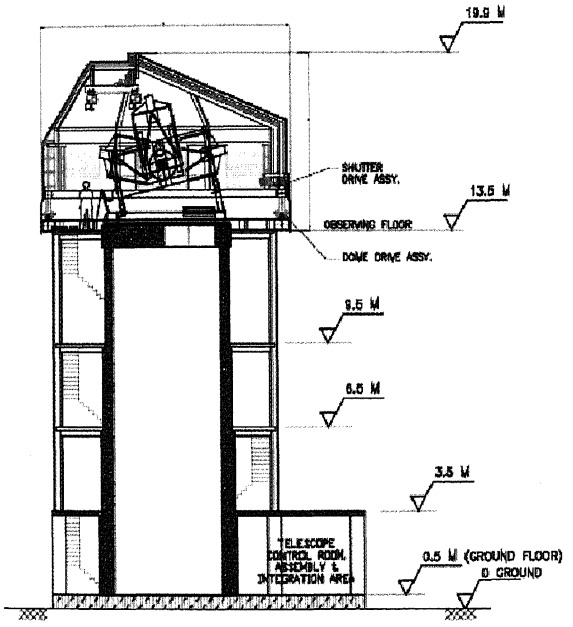
During the course of discussions over the years in the context of attempts to refurbish the 1 metre telescope mirror and supports, it emerged that the need for a wide field imaging telescope at VBO suited for use with modern detectors should be given high priority. After comparing specifications and cost of various options available from vendors, the decision was taken to acquire a 1.3 metre telescope from DFM Engineering in USA, with a telescope mount designed specifically for the low latitude of VBO.

The optical system of the telescope is an F/8 Ritchey Chretien with a 2 element field corrector giving a corrected field of 30 minutes of arc. The expected energy concentration is 85 to 90 percent within a circle of diameter 0.6 seconds of arc (30 microns at the image scale of 20 seconds of arc per millimetre). With contemporary charge coupled devices being used in astronomy, this would allow adequate sampling of the best "seeing" conditions possible at the VBO site.

The telescope will be equatorially mounted using a unique, double horse shoe mount designed for VBO. This will allow longer observations of objects transiting at low elevations to the north and south. The metering structure of the telescope (the Optical Tube Assembly) is a standard design of DFM engi-

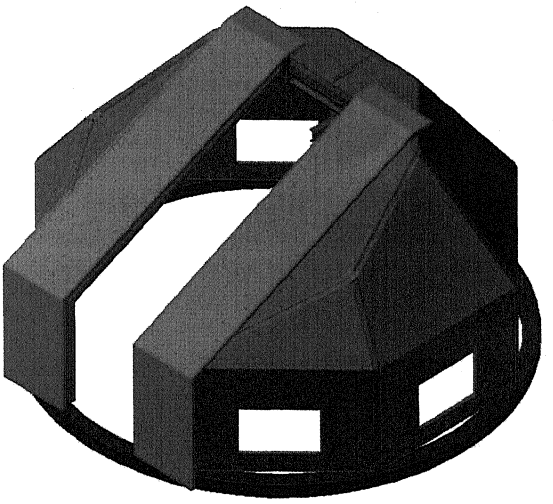
neering with focus compensation using invar spacers. The secondary mirror assembly includes a five - axis positioning system for collimation and focus adjustments. The telescope will be able to support a total instrument weight of 150 kg at 75 cm from the Cassegrain mounting flange.

An instrument mounting interface unit with three ports, and incorporating an autoguider system as well as mechanisms for positioning filters, is planned at the cassegrain focus. A mosaic CCD imager of 4K X 4K pixels is under development at IIA and is planned as the " first light " imager on one of the instrument ports. A Project Instrumentation group has been discussing plans for other instruments, including a multi-fibre positioning unit (up to 30 fibres) to feed a low-to-intermediate resolution spectrograph and an imaging polarimeter. The telescope will be



Sectional elevation of the proposed 1.3 metre telescope enclosure and dome.

housed in an enclosure and dome designed to eliminate the thermal effects which affect dome "seeing".



3D View of 1.3m Dome

The enclosure (building) will be a naturally ventilated steel structure and the dome design minimizes the enclosed volume of air and will have vents/windows for natural ventilation. Enclosed spaces such as the control room will be only at the ground level. The telescope control software can be used for remote operations over the network. The figures shows a sectional view of the enclosure and dome and a 3-D model representation of the dome.

The 1.3m Project is monitored by a Steering Committee and there are three Working Groups associated with the telescope, the enclosure / dome and the focal plane instrumentation. The Project is being executed using the existing manpower in the institute. The mechanical and civil sections of the institute, in particular, are currently closely involved with the ongoing design process for the enclosure / dome. The involvement of other sections will increase as the project progresses. From an engineering point of view, the telescope will probably be ready for installation by March 2010. Efforts are being made towards having the enclosure and dome in place by that time.

(Ashok Pati)

2.12 New Initiatives

2.12.1 HCT Echelle SPectrometer

Steps were taken to proceed to the detailed design of the instrument following the concept design developed during 2007 – 2008.

An RFP was advertised on the IIA website inviting global tenders for the "Design and Development of a High Resolution Spectrometer for the 2-m HCT" in January 2008. The RFP invited proposals for a detailed design including a complete set of fabrication drawings and details of optics, mechanical parts & electronics. It also sought technical partnership in building the full instrument.

Based on technical evaluation and commercial negotiation, Industrial Research Laboratory (IRL), New Zealand was identified for the design and development of HESP where IIA and IRL contribute to the development in a close technical collaboration.

The project envisages strong interaction between IRL and IIA at all stages with members of the team visiting each other to participate in the assembly and the test of various modules. IIA would work on the instrument control (hardware and software), mechanical assembling of spectrometer, fabrication of thermally controlled enclosure, CCD detector system and data handling. The travel costs shall be borne by the parent organization and the local hospitality shall be provided by the host organization.

The HESP proposal was also discussed at the national meeting conducted on September 29, 2008 at IIA. It was attended by representatives from BARC, IUCAA, TIFR, PRL, ARIES and ISRO. The technical as well as budgetary aspects of the proposals were discussed. It was observed that there is sufficient interest in high resolution spectroscopy at a national level and also the instrument can support many science programmes with modest fraction of the telescope time (15%), the building of the instrument should be expedited. It was recommended that the project may be approved with the necessary funding.

A funding proposal was subsequently generated based on these discussions.

(HESP team)

2.12.2 Giant Segmented Mirror Telescopes (GSMTs)

Over the next decade, cutting edge optical and IR astronomy will move from the present 10 m class telescopes to the future Giant Segmented Mirror Telescopes (GSMTs) of diameters over 20 meters, signifying the next major leap in optical and IR astronomy. Such major initiatives are necessitated by our quest for knowledge about the universe we live in. To take these initiatives to a logical conclusion, one may require (a) large human resources, (b) very large financial investments, and (c) technological know-how. No single institute or even a country can afford to build and sustain such mega projects, and therefore need to be planned as collaborative multi-national facilities. Three large ground-based telescopes – Giant Magellan Telescope (GMT) of 25 m aperture, Thirty Meter Telescope (TMT), and the 42 m European Extremely Large Telescope (E-ELT) – are planned to be built by different groups around the world, each of which has several partners cutting across national boundaries. All the three projects have shown equal interest in India's participation in building and using the facilities.

The invitation for participation by all the three consortia necessitates drawing a set of criteria that would enable choosing the best option for the Indian astronomical community. The most important criteria are: (a) Scientific objectives of the community, (b) level of in-kind participation, (c) financial implications, (d) synergy with astronomical facilities in India, (e) technological realization of the projects, (f) access to the existing current large telescopes. The above criteria are evolved through many meetings and discussions, held at institutional and inter-institutional levels, during the period 2008 – 2009.

A national consensus on our participation in one of the projects was arrived at a day-long National meeting organized on 27 September 2008 at IIA. Seventy five members representing a cross section of astronomers from universities and research institutes attended the meeting. The members strongly felt it was an important step for India to keep up with the world community, in the field of optical and IR astronomy, and participation in one of these projects is a significant opportunity not to be missed. This meeting was followed by a meeting between senior representatives of different institutes (IIA, RRI, ARIES, IUCAA, TIFR, PRL, NCRA) and heads of Department of Science and technology (DST), Department of Atomic Energy (DAE) and Science and Engineering Research Council (SERC) held on 25 October, 2008. Subsequent to these two meetings, four institutes (ARIES, IIA (PI), IUCAA and RRI) were entrusted the responsibility of preparing a Detailed Project Report (DPR) on India's participation in one of the projects. To oversee the developments, a national advisory board was also set up. To facili-

tate the preparation of the DPR, five national working groups were formed to make a detailed study on (a) technical aspects of the projects, (b) the science case, (c) industry interface to assess the in-kind contributions, (d) strategy for the human resources development within the country, and (e) setting up of a science center in the country.

As a part of the DPR exercise, a small team of Indian astronomers (Ram Sagar, Ajay Saxena, Ramaprakash and Eswar Reddy) visited the headquarters of the three projects during January 12 – 25, 2009. They held a series of meetings with representatives of the Board of each of the projects. Based on the information obtained during these meetings and the inputs gathered from the national working groups, it became clear that there were two key parameters that differentiated the projects, one being the cost of the project and our affordability and the second being the project's willingness to offer us a greater participation through in-kind contributions. EELT was opted out of our consideration as it was the most expensive option (10% share 2008 base price: INR 1000 crores) of the three. Participation in one of the other two projects, GMT and TMT is now being pursued.

It is now proposed to have meetings with representatives of the Boards of the two projects and the Indian industries to assess the Indian industrial strengths, and the nature of India's in-kind contribution to the projects.

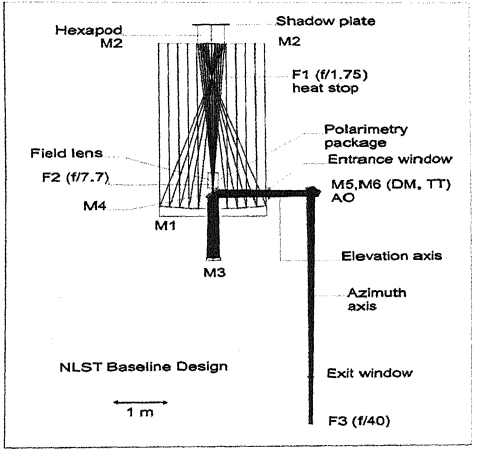
A final decision on the choice of the project will be made based on all the criteria listed above. Participation in either of the projects will bring an array of benefits to the country, both in science as well as the technological know-how, for a future growth of the field.

(B. Eswar Reddy, for GSMT-IIA working group)

2.12.3 National Large Solar Telescope (NLST)

The NLST team worked out the technical specifications of the National Large Solar Telescope based on the scientific goals that were evolved after extensive discussions. A national level technical committee selected MT Mechatronics, Germany for preparing a detailed "Concept Design Report" for NLST since the company has demonstrated capabilities in building a 1.5-m solar telescope (GREGOR). This company submitted a preliminary concept design report in January, 2009 which was reviewed by an international panel and the NLST team in February, 2009.

NLST will be a 2-m f/40 alt-azimuth Gregorian telescope with an innovative design and an effective heat rejection system. It will have an on-axis system, which makes alignment and commissioning much easier. By keeping the number of reflections low, the telescope light throughput is high which is essential for applications like polarimetry and speckle interferometry. NLST contains adaptive optics as a built-in feature to ensure diffraction limited performance. A mechanical turntable behind the telescope moves the whole post focus assembly and so compensates for the rotation of the image due to the alt-azimuth telescope system. The primary mirror is cooled from below to keep it close to the ambient temperature. The heat at the primary focus is removed by reflecting away most of the unwanted light besides cooling the heat stop. Several ports for post focus instruments are possible. The telescope will be an open telescope with a simple retractable dome that will cover the telescope during the time when there are no observations.



Optical Layout of NLST

During the review meeting, it was concluded that a field of view (FOV) of 200 arcsec would be optimal for diffraction limited performance. The review panel suggested that the following aspects be incorporated in the DCDR: (a) A detailed discussion of the hot spots, chromatic aberrations, FOV effects, wavelength transmission along with the risk factors, (b) An increase of the diameter of the turntable from 5-m to around 10-m, (c) A full fluid dynamics analysis of the air flow above the dome.

It is proposed to use NLST for night time astronomy as well. A high resolution spectrograph will be attached to one of the ports available at the F/40 focus. Night time astronomy can be viewed so to speak

as another focal plane instrument of the NLST. Radial velocity measurements of the order of 10 meters per second are possible. Visible wavelengths will be covered. No additional instrumentation needs to be mounted onto the actual telescope and the mechanical properties of the telescope remain unaffected.

(S. S. Hasan & K. E. Rangarajan)

Micro-thermal measurements and data reduction device for site-characterization related to NLST programme

The device measures the ground level turbulence contribution for telescope seeing, at five defined heights (2.5 m, 5.5 m, 8.5 m, 11.5 m & 14.5 m) to determine the optimum height, for the telescope mount, for minimal turbulence. The five channel's absolute temperature sensors of the device were accurately calibrated for its freezing point ($\approx -4°C$ for Hanle/Merak) and their relative calibrations were done at each site. The re-installation and re-commi ssioning of the improved version of the said device, for both sites were completed during March 2009, and another set of devices are also getting ready in the laboratory for the Devasthal site.

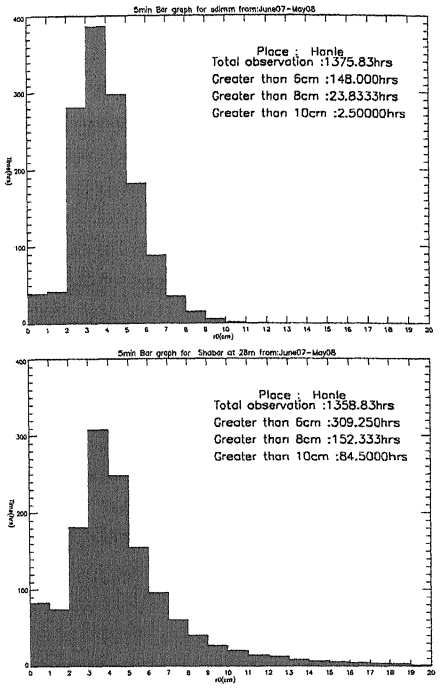
(R. Srinivasan, T. P. Prabhu, K. Dhananjay, M. R. Somashekar, & P. Janakiram, et. al)

Site characterization programme for NLST

Activities of the site characterization program continued vigorously during the year at the two high altitude sites Hanle and Merak, in Ladakh. Efforts have just begun at the Devasthal site in Uttarakhand. The station wise details are as follows:

Hanle: Observations with the Solar Differential Image Motion Monitor (SDIMM) and Shadow Band Ranger (SHABAR) instruments procured from the National Solar Observatory (NSO) continued at the site till October 2008 See figure. The day time seeing measurement device was moved to Merak for calibration of two Meade 12″ telescope-based IIA units and one Celestron 14″ telescope based IIA unit of SDIMM. One of the 12 Meade IIA units was moved and installed on a 4 m tower at the summit near the Himalayan Chandra Telescope (HCT), during the same month. The second Meade 12″ based unit was readied for transport to Devasthal for installation.

The old weather station at the location adjoining HCT continued to be used to record the meteorological data such as irradiance, wind speed and direction, precipitation, humidity and temperature. A new Campbell automatic weather station (AWS), with provision for high cadence observations at 1 Hz rate, was installed at the summit location during February 2009. See photos.

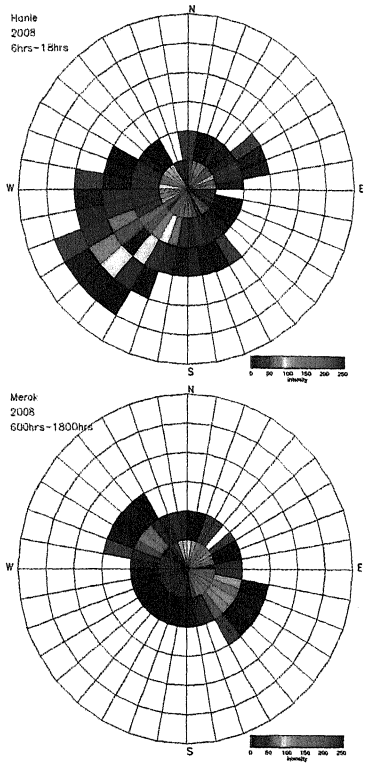


Bar plots of seeing conditions at Hanle in terms of the Fried's parameter in cm. The seeing at the height of the telescope given by the SDIMM instrument and the results from inversion using SHABAR instrument for the seeing at 28 m above the telescope are compared.

The Prede all-weather instruments, an all sky camera and an automatic sky radiometer, continued to yield the sky cloud cover recordings and the irradiance as well as the aerosol measurement parameters at the site during the year. These instruments were moved to the summit in October 2008.

A micro thermal data acquisition system on a 15 m high tower, designed and built at IIA, Bangalore, by the electronics group and the mechanical division, in consultation with the NLST team, was installed at Hanle at the summit location. The high sensitivity probes which were directly exposed to occasional snow fall were often damaged and had to be redesigned. The improved probes were installed at the site in March 2009 and observations started on a regular basis.

Necessary infrastructure was developed at the summit for the above installations and observations. The power requirements, the observation huts, the internet and other communication links were pro-



Polar plots of day time wind conditions at Hanle and Merak stations. The concentric circles represent speeds in steps of 5 meters per second. The wind direction and the colour code for the number of data points are indicated. The heavy winds seen at Hanle are mostly during post-noon hours. The winds at Merak are extremely favorable for good seeing conditions.

vided. A 3 m tower was installed for the all sky camera & sky radiometer, and a 4 m tower was installed for the SDIMM unit. A 15 m tower was erected for the installation of the probes of the micro thermal facility. The entire battery of instruments was thus functional at the summit by October 2008. See photo.

Merak: Observations with Celestron 14″ telescope based IIA-SDIMM unit started at the Pangong lake incursion site in May 2008. Earlier, trial runs were carried out at the camp site starting March 2008. Following the on-field calibration of three IIA units with the NSO unit in October 2008, the NSO unit was installed on a 4 m tower at Merak. Observations also continued with the Celestron telescope based instrument at Merak.

A new high cadence Campbell AWS was installed at the incursion site in February 2009. The old weather station, located at the lake shore close to Merak village, continued to yield the meteorological data during the year.

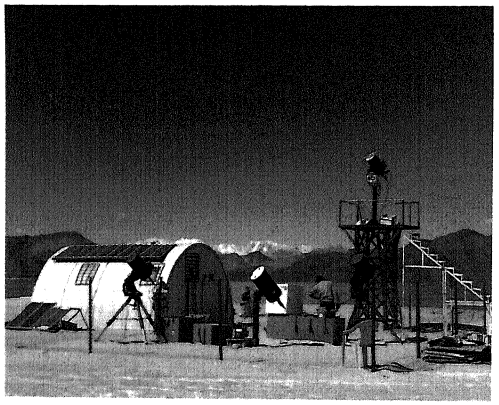
Instruments for site characterization set-up at the summit location at Hanle.

A Prede all-sky camera was installed at the Merak village camp in April 2008 and the cloud cover observations started. During the October 2008 campaign, this camera was shifted to the incursion site and the observations continued throughout the year.

A micro thermal unit with improved probes was installed on a 15 m tower at the incursion site in March 2009. Observations started with this instrument on a regular basis. The earlier version of the device was used intermittently in 2008 for micro thermal observations.

Merak being a small village, about 4 km away from the incursion, the necessary minimum infrastructure had to be provided during the early part of 2008. A camp site was developed in the village. Living facility in a rented accommodation, solar panels, DG sets, FRP huts were all in place by mid 2008. Internet and communication links were also provided both at the camp and at the observing sites. Observer's huts and power facilities were provided at the incursion site simultaneously as seen in the photograph.

Devasthal: A survey was carried out at Devasthal, and the best possible location was identified. The selected location is close to the one proposed for the 3.6 m stellar optical facility of ARIES. Here, the sky opens up southward and the prevailing winds flow unobstructed. A new AWS and an IIA built SDIMM unit were dispatched to ARIES. A tower with slide off roof is being built at Nainital and it will be installed shortly at Devasthal. Ready to build components of a 15 m tower have also been dispatched to ARIES for installation of a micro-thermal device. Certain administrative formalities for use of the identified land are being carried out by ARIES and it is expected that the installation of above instruments can take place by mid 2009.



Battery of instruments and the observing hut at the Pangong lake incursion site, Merak.

NLST lab at IIA, Bangalore: All the planning and monitoring of the programme were carried out from this lab. Observational data is downloaded from both Hanle and Merak stations on a daily basis. Development of software for analysis and application of various inversion techniques is carried out. Scientific and technical discussions, seminar and presentation meetings are conducted regularly. The observing programme of field stations by participating scientists and research/ engineer trainees of NLST is carried out. The following colleagues served as Guest Observers during the period of this report: Satyanarayana, A., Girijesh Gupta, Ravinder Banyal, Ravindra, B., Raju, K. P., and Nagaraju, K.

Highlights of results so far: The day time sky conditions have now been studied for a period of over two years at Hanle. Observations at the Pangong lake site Merak cover a period of over one year. Detailed analysis of the data is in progress. The conditions at Hanle are found to be good during the morning hours but the afternoon periods are generally lost to heavy wind conditions. The Merak site holds the promise of being an excellent site for a large solar facility, of the kind proposed for NLST. The conditions at the Devasthal site will be evaluated on the same lines as is being done for the above two sites.

(S. P. Bagare, S. S. Hasan, A. K. Saxena, T. P. Prabhu, J. P. A. Samson, K. E. Rangarajan, Angchuk Dorje, Rajendra B. Singh, Namgyal Dorjey, Neeharika Verma, T. G. Aditya, Sangita Kumari Padhy, Thubstan Dorje, Md. Ismail, N. Vasantharaju, Dorjai Tsewang, K. Dhanajnay, Y. Pavan Kumar Sarma, N. Shantikumar Singh, Jorphali Sonam, Mahay Tashithsering, Rigzen Wangchuk, R. Norbo, Dorje Tseten, Yanchan Dolma, J. Manoharan, P. Janakiram, T. Sasidharan & N. Thimmaiah)

2.12.4 Visible Emission-Line Coronagraph

A space-based visible emission line coronagraph has been proposed involving all the major Institutions of India, who are interested in solar physics, such as Indian Institute of Astrophysics, Bangalore; Udaipur Solar Observatory, Udaipur; ISAC, Bangalore; LEOS, Bangalore, SAC Ahmedabad; Aryabhatta Research Institute of Observational Sciences, Nainital; and Radio Astronomical center, Ooty. The coronagraph is planned to be around 2013 by ISRO.

The origin of coronal heating is one of the unsolved problems in solar physics. A wide array of theories for heating the solar corona, to temperatures of million degrees have been proposed. It is widely accepted that energy for heating is provided to the corona by some combination of processes. In quiet regions, microflares or nanoflares have been postulated to play an important role in moving energy into the corona. In active regions, transient X-ray and EUV bursts may play a role in the heating. In addition, coronal waves are postulated to be one of the mechanisms for heating the solar corona, waves with periods between 0.1 and 1 s could play a significant role in heating the solar corona. These fast-mode MHD waves contribute 1% of the total power and could play a part in heating the coronal plasma to millions of Kelvin. They can be observed either as the intensity oscillations of a spectral line or of the continuum, or as the velocity oscillations in the Doppler profiles.

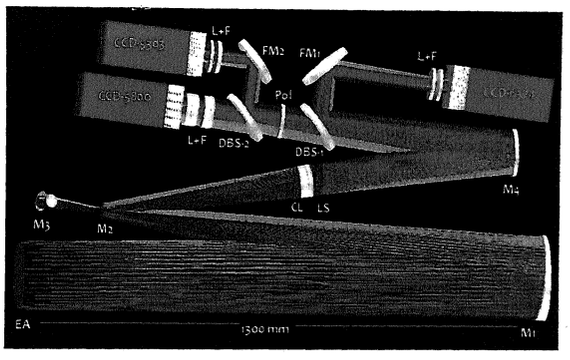
Attempts have been made, during the occurrences of total solar eclipses to detect, confirm, and to determine, the nature of waves. Singh et al. (1997, Sol. Phys., 170, 235) found the intensity oscillations in the 0.02 – 0.2 Hz range with amplitudes of 0.2% to 1.3% during the 1995 eclipse and Cowsik et al. (1999, Sol.Phys.,188, 89) and Singh et al. (2009) confirmed the existence of waves from the 1999 and 2006 eclipses. Philips et al. (2000, Sol. Phys., 193, 259) and Williams et al. (2001) reported successful CCD observations of 6 s oscillations during the 1999 eclipse but was inconclusive for higher frequencies. Pasachoff (2000, Sol. Phys., 195, 281) obtained a series of coronal images using two CCD cameras during the 1999 eclipse and suggested the presence of enhanced power, particularly in the 0.75 to 1 Hz range and they concluded that MHD waves remain a viable method of coronal heating. Singh et al. (1999, PASJ, 51, 269; 2002, PASJ, 54, 793; 2003, ApJ, 585, 516; 2005, Sol. Phys., 226, 201) made spectroscopic observations of the visible emission line profiles for

various types of coronal structures. They found that the width of red line at 6374 Å(sensitive to 1 MK temperature) increases with height, whereas that of green line at 5303 Å(sensitive to 1.8 MK temperature) decreases with height above the limb. The intermediate temperature emission lines do not show much change in width with height. The existence of waves in the solar corona is expected to cause increase in linewidth with height. The different behaviour of coronal emission line with height imposes certain restrictions on the existing models of coronal heating. The proposed space coronagraph is to address the existence and nature of waves to delineate the role of various processes in heating up the coronal plasma. In addition, it is also aimed to study the dynamics and formation of coronal loops, temperature structure of the solar corona, origin and acceleration of CMEs, space weather and magnetic topology of the solar corona.

Methodology : Most of the spectroscopic observations of the solar corona have been made in the EUV and UV wavelength range from space borne experiments and in the visible range from ground-based coronagraphs. The images of the solar corona are obtained in continuum with low spatial and temporal images and are not suitable for such studies. Hence, it is proposed to take the images of the solar corona with a high cadence of about 300 ms in the green at 530.3 nm and red at 637.4 nm emission lines due to [Fe xiv] and [Fe x] ions respectively. The green and red emission lines represent plasma at temperature of about 1.8 and 1.0 million K. These are strong emission lines in the visible part of the spectrum and high efficiency of detectors at these wavelengths makes it possible to take images with high cadence. The images of the solar corona will be obtained to cover the coronal region from 1.05 to 1.5 solar radii with pixel resolution of 1.4 arcsec to study the emission corona and from 1.05 to 3.0 solar radii in continuum to study the CMEs and large coronal structures. Images will also be made using polaroids to study the magnetic topology of the solar corona.

Specific features of the proposed space corona: In principle, one can study the solar corona in the visible part of the solar spectrum, using the ground-based instruments. But the large scatter of the sun by the earth's atmosphere and the varying transparency of the sky makes it impossible to detect low amplitude variations in intensity those may be present due to existence of waves. The data will be obtained close to the limb and with high cadence which is not possible to do with the existing space-based instruments. The data will provide a large data-base required for the above mentioned studies.

The figure shows the conceptual design (using the ZEMAX optical software) of the baseline design configuration which is the three detector based coronagraph.



Schematic of the payload. EA is the entrance aperture and M1 forms the image of the sun on M2, which allows disk light towards M3 and reflects coronal light towards collimating lens (CL). Collimating lens forms the image of entrance aperture at LS, where lyot stop is placed to remove the scattered light. M4 and few additional lenses together form the image according to the requirement. Dichroic beam splitters (DBS 1 and DBS 2) are used to separate the wavelength band. DBS 1 separates red and green bands. DBS 2 is used to separate 5303 and 5800 wavelength bands. A triplet is used for imaging in continuum. FM is a folding mirror for reducing the box length. Total optical weight of the payload is 10 kg and the volume is 1.7 0.7 0.30 m3.

An entrance aperture (EA) of 160 mm allows the full Sun and the corona to fall on the off-axis parabolic (OAP) mirror. An off-axis parabolic primary mirror of clear aperture 20 cm is used to form the primary image at its focal plane and away from the entrance aperture by a distance of 5 cm. The mirror (M2) consists of a central hole placed at the prime focus and allows the disk light through the hole and reflects the rays corresponding to $\pm 1.05R$ to ± 3.0 R towards a collimating lens, which images the entrance aperture at a distance of 20 mm from its last surface, which is achieved in combination with curved mirror M2. Lyot stop is placed at the pupil plane to remove the diffraction effects due to edges of the entrance aperture. The collimated beam is imaged according to the required plate scale using an off-axis mirror M4 along with few lenses.

Three imaging systems have been designed for imaging in 530.3 nm, 637.4 nm and continuum. The component details of the design are given below. The designs were optimized for diffraction limited imaging.

Status of the Project: The scientific objectives of the project has been discussed in a number of national meetings and reviewed by many committees and agreed upon. The optical design has also been reviewed a number of times and approved. After discussions at various levels and vendors it was been decided that the reflecting mirrors will be fabricated at LEOS, Bangalore and other optical components will be procured from different companies in India and abroad. The detectors will be developed at SAC, Ahmedabad, using CCD chips fabricated at SCL, Chandigarh. The backend electronic is planned to be developed at ISAC, Bangalore. The mechanical structure will be developed using the various facilities available in India. All the components of the coronagraph will be tested, calibrated and integrated at the MGK laboratory of IIA and other laboratories of ISRO.

Observations: The CCD detector will be of 2 K x 2 K format, capable of providing 16-bit data with read -out speed of 5 M Hz. It is planned to make observations, in different modes, to meet all the scientific objectives. For intensity variations, CCDs may be binned to achieve high cadence, and for loop dynamic observations, may be made without binning, to get full spatial resolution. For CME studies, observations may be made with relatively large intervals, to observe the solar corona for a larger time, limited by the data storage capacity and telemetry speed. There will be flexibility in making observations by choosing different combinations of binning CCD camera, selecting the region of interest, exposure time and interval, between the frames for different scientific goals.

The report is being submitted to space commission for the final approval of the project and it is expected to take three years to develop and launch the coronagraph after the approval.

(Space Coronagraph Team)

Chapter 3

Student Programmes & Teaching Activities

3.1 Ph.D. Programmes

IIA has launched two new major teaching programmes this year. The first is an Integrated MSc-PhD programme under the aegis of a memorandum of collaboration with the Indira Gandhi National Open University, that recruits students with Bachelor's Degrees. The normal duration of the programme is six years, including two years of a Masters Degree. The first batch of three students started the programme in August, 2008. An Integrated MTech-PhD(tech.) programme, geared towards research in instrumentation, was also launched under a memorandum of understanding with Calcutta University. The M.Tech component of two years duration consists of two semesters of course-work at Calcutta University, and two semesters of internship and project work at IIA. The students would then go on to do a PhD, which is expected to be completed in four years. The first batch of six students started their first semester of the programme in September, 2008.

IIA's existing PhD programme continues. In order to reach a wider pool of candidates for selection into the programme, written admission tests were conducted in eleven centres across the country in April, 2008, an in fourteen centres in December, 2008, which included IIT-Delhi, University of Mumbai, University of Madras, Guwahati University, Barkatullah University, Bhopal, University of Rajasthan, Jaipur and Utkal University, Bhubaneswar. Conducting these examinations gave the involved IIA staff an opportunity to give scientific lectures in these Universities as well as make presentations on IIA's activities. Eight students joined the IIA-PhD programme - 2008, raising the total number of students to forty.

3.2 Experimental Physics Lab

The laboratory courses of the Integrated MSc-PhD Programme in Physics are an important component of the programme. The goal is to expose students to a variety of fundamental concepts and measurement techniques through a set of instructive experiments, and has been designed by keeping in mind that learning science must involve understanding the rigour of the scientific method.

The first batch of integrated Ph D students in IIA has carried out about ten general physics experiments in the first semester (September 2008 – December 2008). These experiments are carefully selected to cover the important areas of basic physics. The experiments include the measurement of universal gravitational constant with Cavendish's torsion balance, the determination of the Planck's constant from photoelectric effect and blackbody radiation spectrum, the measurement of speed of light using Foucault rotating mirror technique, electronic charge measurement from the Millikens oil drop experiment, finding the e/m ratio using Helmholtz's coil, measurement of Coulomb's constant from electrostatics and the verification of Faraday's law.

At component level, each experimental module is designed with simple, open and detachable parts. This way, students can greatly appreciate the functionality of each component, quickly assemble the experiment and make a suitable modification in its parts if desired. This was seen as essential to avoid passive learning in a black-box kind of approach to experiment where the interior of the instrument often remains a complete mystery to students.

Each experiment required careful equipment setting, device calibration and fine adjustments before making the actual measurements. Most of the experiments also have computer interface for instru-

ment control, data acquisition and analysis. While doing experiments, students were encouraged to initiate open discussions, and also actively participate in interactive sessions and tutorial classes.

Since these classic experiments also mark the important milestones in the advancement of physics during the last century, with the available resources, the students could learn to explore the historical significance of landmark discoveries and important breakthroughs in physics. It was also an opportunity to learn about the distinguished scientists whose contribution markedly changed the scientific landscape of our time. Most importantly, the lab course helped them to refine their understanding of complexity and ingenuity of great experiments in the evolution and the development of scientific ideas.

(R. Banyal, B. R. Prasad, S. Chatterjee & U. S. Kamath)

3.3 Advanced Course: Extrasolar Planets

An advanced level course consisting of five lectures on Extrasolar Planets, titled Planetary Systems Orbiting Diverse Stars was given by Dimitar Sasselov, Professor from Harvard University USA, who is a visiting expert in the field. Several faculty members in addition to students, attended the in-depth lectures on this exciting and frontier field of astrophysics.

3.4 Completion of Ph.D.

M. Sampoorna, successfully completed her Ph D in 2008, under the guidance of *K. N. Nagendra*. She submitted her PhD thesis to IISc on April 2, 2008, and the degree was awarded in December 2008. The Title of the thesis is: *Polarized Line Formation in Turbulent and Scattering Media*, and focussed on two specialized front-line topics of current interest in the area of Solar Physics, namely the theory of polarized light scattering and spectro-polarimetry.

Malay Maiti worked under the supervision of *S. Sengupta* for his thesis on *Theory and observation of brown dwarfs*. He has submitted his thesis in March 2009 to the Faculty of Science, Mangalore University. He has worked on observation of optical variability (in R and I band) from a few bright brown dwarfs.

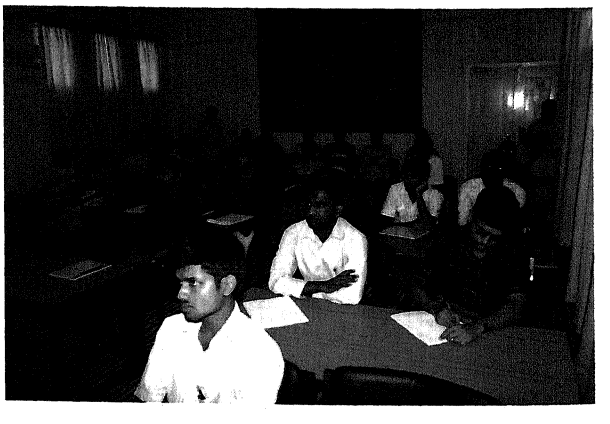
K. Nagaraju under the guidance of K. E. Rangarajan submitted his thesis to the Mangalore university in July, 2008. The thesis was titled *Spectropolarimetry of Active Regions on Sun*. As a part of the Ph.D. work, a dual beam polarimeter was designed, fabricated and installed as a backend instrument at Kodaikanal tower telescope (KTT). In conjunction with the existing high resolution Littrow type Spectrograph, it forms a powerful tool to measure the magnetic fields on Sun. Velocity and magnetic fields of several active regions on the Sun were measured using the above instrument in different spectral lines formed at photosphere and chromosphere.

J. P. Lancelot was awarded Ph D degree for his thesis entitled *Wavefront Sensing for Adaptive Optics* by the Bangalore University. The research involved the theoretical formulation and experimental demonstration of a new wavefront sensor based on the polarization shearing interferometry technique using two crossed Babinet Compensators as a shearing device, with specific application to astronomical adaptive optics systems. It has the advantage of obtaining the x-shear and y-shear simultaneously. The suitability of this new wavefront sensor and the efficacy of the method have been established in this dissertation.

3.5 Summer Programmes

IIA conducted a summer course for Masters level students on introductory astrophysics at the Vainu Bappu Observatory during 15–22 May, 2008, and a summer school in Physics at the Kodaikanal Observatory during 9–21 June, 2008.

At the VBO school, there were twenty participants, all post-graduate students from the universities and IITs. The school was inaugurated by Ajay K. Saxena, Dean (E), on May 15, 2008 at the new lecture hall set up at the observatory.



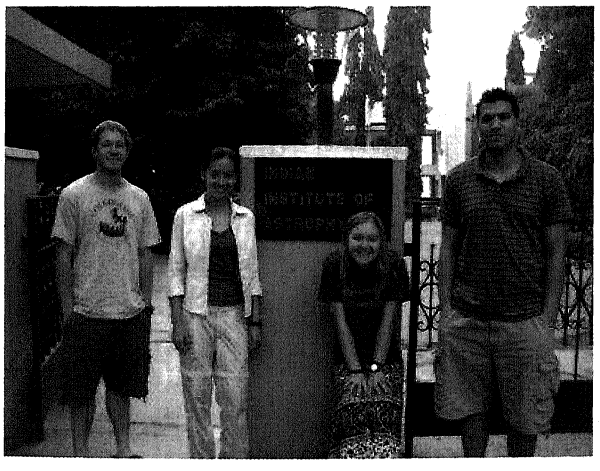
A session of the VBO summer school

The school covered a broad range of topics in observational and theoretical astronomy starting with the very basics, and both faculty and PhD students from IIA gave lectured at the school. There were also tutorials organised by C. Muthumariappan (Resident scientist, VBO), along with K. Jayakumar, K. Kuppuswamy, and M. J. Rosario.

The students had an opportunity to take stellar as well as calibration spectra with the UAGS instrument at the Zeiss Telescope. They also reduced spectra from the echelle spectrograph on the VBT.

Thirteen of the students then spent eight weeks at IIA during May-July, 2008, to participate in IIA's regular summer projects. In addition, four students from BITS, Pilani, did their "Practice-School II" projects in IIA during 6 January –15 June, 2008. In addition, several students from various universities carried out scientific projects at IIA.

At the Kodai school, there were thirty participants (ten B.Sc. students and 20 M.Sc. students) from institutions all across the country. The topic of the school was "Experimental Physics", with a focus on the Solar observations and analysis.



IRES students visitng VBO

3.6 International Research Experience for Students

The IRES programme, which is for graduate students of the United States to study astrophysics in India, is administered by the National Solar Observatory, Tucson, USA, and is currently co-ordinated by Kiran Jain from NSO, herself an alumnus of IIA. The programme aims to expose potential researchers to an international setting at an early stage in their careers. 2008 was the second year of the programme at IIA. Four students, Andrea Malaika Kunder, Catharine E Wu, Erik Larson, and Driss Takir, spent June 13 – August 7, 2008 at IIA. Apart from visits to IIA's field stations, they did research projects mentored by S. Giridhar, U. S. Kamath, S. P. Bagare, and S. K. Saha.

Swapan Saha

3.7 Kodai School on Synthesis of Elements in Stars

The Kodai School on Synthesis of Elements in Stars was held at the Kodaikanal Solar Observatory of the Indian Institute of Astrophysics from April 29 to May 13, 2008. It was organized to provide a glimpse of this exciting area of astrophysics to astrophysicists of tomorrow and to motivate young students. The 110-year old Kodaikanal Solar Observatory, with a history of significant scientific achievements, provided an ideal and inspiring setting for the school. The student participants, numbering a total of thirty four, were from different universities and research organisations all across the country. There were three international students, two from Brazil and one from Germany. Apart from the regular classroom lectures, students had ample time for informal discussions among themselves and with the school faculty.

The school drew strength from considerable in-house expertise at IIA in a number of critical areas. A highlight of the school, however, was the faculty participation by a number of leading astrophysicists from different parts of the world. Apart from the six members from IIA, the school faculty included Marcel Arnould (Director, Institut d'Astronomie et d'Astrophysique, Université Libre de Bruxelles, Belgium), David L Lambert (Director, McDonald Observatory, University of Texas at Austin, USA), Bruce Fegley and Katharina Lodders (Washington University, St Louis USA), Simon Jeffery (Armagh Observatory, UK), Amanda Karakas (Mount Stromlo Observatory, Australia), Alak Ray (TIFR, Mumbai) and Kamalesh Kar (SINP, Kolkata).

David Lambert set the tone of the scientific sessions with the lead talk on "Synthesis of elements in stars: an overview". In two subsequent lectures, he also discussed "The elements beyond the iron peak". "The basic properties of nuclei" were explained by Arun Mangalam (IIA) in a series of lectures and hands-on sessions which included solving problems. "Cos-

mological nucleosynthesis of light elements" was discussed by C. Sivaram (IIA). These lectures provided the background for the series of lectures by other speakers that followed.

Massive stars, their evolution and nuclear reaction rates were discussed by Ray. He also discussed core-collapse in massive stars and supernovae in brief. In a series of lectures, Lodders gave a vivid picture of the present understanding of Elemental abundances: solar, meteoritic and outside the solar system. Estimation of condensation temperatures, a property of the chemical elements which is of great astrophysical importance, was explained by Fegley during his lectures on Cosmo-chemistry of the major elements.

A number of classes were devoted to the studies on stellar evolution: basic equations, elementary solutions and numerical methods. These classes were conducted by Jeffery. As a part of these lectures, the students were introduced to a tool called Window to the Stars, an interactive visualisation tool for running stellar evolution models. Students actively participated in this programme learning the uses of this tool. AGB nucleosynthesis, that plays a significant role in the understanding of C, N, O abundances in ISM and the production and distribution of s-process elements, was discussed by Karakas. Starting with a broad overview of the evolution of low- and intermediate-mass stars, Karakas discussed in depth nucleosynthesis prior to the AGB phase, evolution and nucleosynthesis during the AGB phase, and evolution after the AGB phase and super-AGB stars. She also discussed in brief Low-metallicity evolution and nucleosynthesis. Chemical composition of stars determined from high-resolution stellar spectra provide important observational constraints for theoretical studies of stellar nucleosynthesis and chemical evolution of the Galaxy, its origin and structure. Aruna Goswami (IIA) discussed some current issues in the understanding of the Galactic chemical evolution. Gajendra Pandey (IIA) explained how stellar spectra can be analysed using the Curve of growth technique. Kameswara Rao (IIA) talked about the high-resolution echelle spectrograph at VBO (the only high resolution spectrograph in India, of $\frac{\lambda}{\Delta\lambda} \approx 60,000$), and some results from it. Some concepts and techniques of stellar classification, including automated classification and stellar parameterization were introduced by Sunetra Giridhar (IIA).

The importance of weak-interaction rates for stellar evolution, supernovae and r-process nucleosynthesis was discussed by Karakas. She also discussed weak interaction processes during the proton-proton cycles and the solar neutrino problem. In a series of talks titled "The evolution of massive stars and the concomitant non-explosive and explosive nucleosynthesis", Arnould gave a comprehensive picture of the present understanding of explosive nucleosynthesis. His lectures covered a number of important problems that are yet unresolved but are crucial for our understanding of stellar nucleosynthesis. The scientific sessions ended with his talk on p-process nucleosynthesis to which the production of proton-rich elements is attributed, a topic of great importance but less explored as yet. It was evident from the feedback received from the participants that periodic organisation of such an event will go along way in motivating students to choose astrophysics as their career. Aruna Goswami, Eswar Reddy and Gajendra Pandey were co-ordinators of the school.

(Aruna Goswami)

3.8 The Second IIA-PennState Astrostatistics School

The second IIA-PennState Astrostatistics school was held at VBO, Kavalur during July 9 to 16, 2008. The practice of modern empirical astrophysics involves a two-pronged challenge. On the one hand there is a compelling need for rigour in the application of the state-of-the-art statistical methods. On the other, the recent paradigm shift that involves routine mining of large multi-wavelength datasets, necessitates complex automated analytical processes that invoke a very diverse set of statistical techniques. The IIA-PennState Astrostatistics schools are a response to this challenge. As with the first school in 2007, this school too was designed to meet the challenge by providing a strong conceptual foundation in modern statistics as well as a repertoire of state-of-the-art statistical tools applicable to astrophysical problems.

These schools are distinctive as they are a part of a collaborative effort between IIA, the Center for Astrostatistics of Pennsylvania State University, USA, and the Indian statistical community, which was begun with the 2007 s school. From the response to the first school, it was clear that the need for such a school in India is a very pressing one.

The school was open to astrophysics practitioners at all levels. While the first IIA-PennState School in 2007 was restricted to affiliates of Indian institutions, this year the school was international. There were a total of 31 participants that included four members from IIA, six from the Indian university sector (two

A tutorial session of the IIA-PennState Astrostatistics school

faculty and four PhD students), besides those from other astrophysics research institutes of the country, viz., IISc, RRI, ISAC, PRL, TIFR and IUCAA, and abroad. In terms of background, twenty were graduate students including four from overseas institutions, viz., Tel-Aviv University (Israel), Max-Planck Institute of Astrophysics (Germany), and University of Geneva (Switzerland). There were three post-doctoral fellows and eight tenured scientists/faculty.

Besides Jogesh Babu of the Center for Astrostatistics, PennState University, USA, the resource persons of the school were Rahul Roy (Indian Statistical Institute, Delhi), Bhamidi V. Rao (Indian Statistical Institute, Kolkata), Sushama Bendre (University of Hyderabad), Mohan Delampady (Indian Statistical Institute, Bangalore), Thriyambakam Krishnan (Cranes Software International, Bangalore) and Arnab Chakraborty (Statistical Consultant, Kolkata). Apart from lectures on modern statistical concepts, a heavy emphasis was placed on lab sessions that demonstrated the use of statistical tools appropriate to astrophysical problems. Astrophysical data sets for the tutorials were compiled primarily by Eric Feigelson of the Center for Astrostatistics, PennState. For the purposes of these sessions, Anbazhagan Poobalan and his computer management team at the Vainu Bappu Observatory set up 32 multi-platform laptops in the lecture hall with the R software installed, and networked them to a local data-server. R is an open-source, multi-platform software environment, which is the current standard in research-level statistical computation. The tutorial sessions were conducted by Arnab Chakraborty.

A new feature of this school was the introduction of the topic of Time-Series Analysis, which was done by Arnab Chakraborty. Another new feature of the school was that special brainstorming sessions were organized for participants to present a description of their own on-going research problems to the statisticians. Those participants, who made use of this feature, then presented a summary of their problems and the inputs from the statisticians, to the whole school.

Prior knowledge of statistics was not a pre-requisite for the course. As many participants observed, it had an optimum blend of commonly used prescriptive methods and their theoretical foundation, which would help them in their future research, particularly in their choice of statistical tools. This was also evident in the participants questions during the sessions and afterward, and during the participants presentations on their research problems.

The tranquil venue of the Vainu Bappu Observatory greatly facilitated the intense engagement that was demanded of the school. Apart from the pedagogical activity, the coming together of astrophysicists and statisticians reinforced once more the very real need for further collaborations between the communities. Although the dates of the school were selected to coincide with the lull-period in observing activity, the participants and statisticians did have an opportunity to do sky-watching during the post-dinner hours.

The statistics lectures were brought out in the form of Lecture Notes, hard copies of which were made available to the participants at the start of the school. The website of the school is being maintained, and all the lecture notes as well as the tutorials and data sets are available on IIA's website.

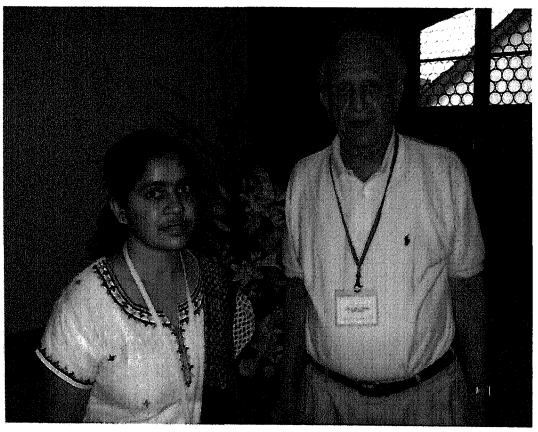
The assiduous team effort of the organising committee which had Anbazhagan Poobalan, K. Kuppuswamy, Ravinder Banyal, C. Muthumariappan, Margarita Safonova, and Firoza Sutaria in addition to Prajval Shastri (Chair) and Sabyasachi Chatterjee, and the able administrative support provided by S. B. Ramesh, A. Narasimharaju, K. Shankar, K. Mohan Kumar and K. Lakshmaiah, along with the absolutely meticulous execution by the Vainu Bappu Observatory team, made for the organisational success of the school. Prajval Shastri and Sabyasachi Chatterjee were the co-ordinators of the school.

(P. Shastri & S. Chatterjee)

3.9 Student Activities & Achievements

IIA Student at the Nobel Laureates Meeting, Lindau

M. Sampoorna was among the outstanding young scientists selected to participate in the 58th Meeting of Nobel Laureates with students/ young researchers, held at Lindau, Germany, during 29 June – 4 July 2008. The meeting was attended by 25 Nobel Laureates in Physics, and more than 500 young researchers from 67 countries. Sampoorna particularly discussed with Professors William Phillips, Roy Glauber, Brian Josephson, David Gross, and George Smoot. During this visit, she had the opportunity to meet and discuss on matters related to the "Future of Indian Science" with the then Minister of Science and Technology, Shri Kapil Sibal. She also met several young researchers, particularly from Belgium, USA, Spain, Germany, and China.



M. Sampoorna discussing with the Nobel Laureate Prof. Roy J. Glauber during the 58th Meeting of Nobel Laureates with students/ young researchers, held during 29 June – 4 July 2008. This meeting was devoted to Physics. Prof. Roy J. Glauber received the Nobel prize in 2004 for his contribution to the "quantum theory of optical coherence", closely related to her field of research.

L. S. Anusha participated in the workshop on "Etudes a haute resolution de l'atmosphere solaire: de la photosphere a la couronne," Nice, France, October 21 – 23, 2008. She attended the Evershed meeting on "Magnetic Coupling between the Interior and the Atmosphere of the Sun", December 2 – 5, 2008 at Bangalore.

G. R. Gupta attended the Evershed meeting on "Magnetic Coupling between the interior and the atmosphere of the Sun" at IIA, Bangalore during December 2 – 5 2008. He also attended the 25th ASI meeting, held at IIA, Bangalore during February 18 – 20, 2009.

M. Sampoorna participated in the international conference on "Magnetic Coupling between the Interior and the Atmosphere of the Sun, Centenary Commemoration of the discovery of the Evershed Effect", held at IIA, Bangalore, India, during 2 – 5 December, 2008.

Veeresh Singh participated in "37th Committee on Space Research assembly", held at Montreal, Canada during 13 – 20 July, 2008. He also participated in a conference on "Low Frequency Radio Universe," NCRA, Pune, 8 – 12 December, 2008. He also took part in the "27th ASI meeting," IIA, Bangalore during 18 – 20 February, 2009.

Two senior students Blesson Mathew and Bharat Yerra participated in a discussion with Dr K. Kasturirangan on a programme entitled India's Future space missions telecast by NDTV during July 2008.

Six IIA students, Avijeet Prasad, Arya Dhar, Manpreet Singh, L. S. Anusha, B. P. Hema and C. H. Anantha participated in the Republic Day Parade on January 26, 2009 at New Delhi, where a float on Astronomy designed and executed by IIA was part of the parade.

3.10 Individual Teaching activities

S. P. Bagare is guiding Ph.D. students of Physics Research Centre, Virudhunagar. A co-guided student, Mr. B. Karthikeyan was awarded Ph.D. by the Madurai Kamaraj University (MKU), in January 2009, for his thesis on *Studies of molecular species identified in solar and allied spectra by spectroscopic techniques.* Ms Ann Mary Francis was guided for her M. Phil dissertation, submitted to MKU in June 2008.

S. P. Bagare & K. E. Rangarajan are teaching a course on physical astronomy to final year students of the five year Integrated M Sc at the Dept. of Physics, University of Mysore.

D. Banerjee is presently supervising one PhD student from JAP programme (Mr. Girjesh Gupta), one from IIA programme (Mr. Chandrashekhar) and Co-guide of another IIA student (Mr. Krishnaprasad); Teaching in JAP programme (the course on *Fluids and Plasmas*); Teaching in Integrated Phd Programme (*Electrodynamics*); Teaching in Integrated M.Tech (PhD) programme, (*Sun and stars, structure and evolution*), part of survey course; Banerjee has delivered series of introductory lectures on *Sun*, for the summer project students at Bangalore.

S. Chatterjee gave a talk on Raman Effect at the Kodai summer school on physics on June 19, 2008. He gave a set of eleven lectures on the topic of 'Optics and Inversion' at Udaipur Solar Observatory from 13–22 October 2008. He co-organised the Second IIA-PennState Astrostatistics School, July, 2008, Vainu Bappu Observatory, and lectured on the topic *Relevance of Astrostatistics & some Historical Remarks.* He taught a course at the Mohan Lal Sukhadia University, Udaipur on "Optical and Near IR studies of stars and galaxies", to the M.Sc. students who specialise in astronomy. The course consisted of eight lectures and was held between 15th and 20th January, 2009.

R. T. Gangadhara taught *Radiative processes in Astrophysics* for IIA/JAP/RRI semester I course work of JRF during August – December, 2009. He also taught the course *Electrodynamics* during January – April, 2009 for IIA – IGNOU IPhD semester-II. *R. T. Gangadhara* also guided Mr. Reji Mathew Thomas (SRF, IIA) for his PhD thesis project on *Radio Pulsar Emission Geometry and Mechanism.* He was awarded the PhD degree in December 2009. He also guided a summer project student Miss. Soumya Aiholi for her project on *Observational Aspects of Pulsar Polarization* during May 13 – July 15.

S. Giridhar guided an IRES student Andrea Kunder for her project on *Quantitative Spectral Classification using Artificial Neural Network* during June – August, 2008. *Giridhar* has been guiding S. Sumangala Rao, a PhD student of IIA for her PhD work on *RV Tau and other post-AGB Stars since May 2008.*

A. Goswami and *C. Sivaram* taught the following courses to IIA and JAP students: "Stellar and high energy physics" for the semester beginning January – May 2009 and "Nuclear and particle physics" for the semester February –June 2009 for the IPhD students.

S. S. Hasan is supervising the doctoral research of G. Vigeesh, a Ph.D. student at IIA.

Under the guidance of *K. M. Hiremath*, Mrs. M. R. Lovely, is working for her PhD thesis entitled *Study of Dynamics and Magnetic Field Structure of the Solar Convective Envelope using Sunspot Activity. Hiremath* is also co-guiding, a Hungarian student, Mr. Ivan Molnar's PhD thesis entitled *Consideration of the Magnetic Fields of the Solar Core on the Basis of Chandrasekhar's Equations.* The main guide of this student is Dr. Grandpiere (a solar physicist), Konkoly Observatory of the Hungarian Academy of Sciences, Hungary. *Hiremath* also guided a summer school student, B. B. Akshatha, M Sc(Physics), Department of Physics, Mangalore University. She completed her project titled *Thermal Structure of the Sunspots during their Initial Appearance.*

U. S. Kamath gave lectures on *Spherical Astronomy* and related topics at the Calcutta University during 8 – 13 September and 22 – 26 December 2008, for the CU – IIA integrated M.Tech – PhD programme. He was part of the team which supervised students for the "Physics Lab" for the IIA – IGNOU I – PhD programme. He also mentored students of Indo – US IRES programme, Catharine Wu, New Mexico State University, for the project *Photometric and Spectroscopic Study of Nova IV Cep 1971 in Quiescence* during 16 June – 6 August, 2008. He also guided Mr. Ratnakumar for the project *Periodicity in Nova Light Curves* during February – June, 2009, a second semester JRF students.

R. Kariyappa guided Mr. L. C. Pradeep, for his project work on *Study of Small Scale Structures of the Sun from Hinode Observations* under Summer Project Programme of BGS during May – July 2008. He also guided an M. Phil student (Mr. S. T. Kumara) of Department of Physics, Periyar University, Salem (2007 – 2009). *R. Kariyappa* also co-guided Mr. S. T. Kumara for his PhD thesis on *Understanding the Solar Variability from Spatially Resolved Images* at the Department of Physics, Bangalore University, 2008. He also co-guided Mr. Devaraj, for his M Phil Thesis dissertation on the topic: *Solar Spectrum - Fraunhofer Lines*, Annamalai University, 2008.

J. P. Lancelot gave lectures on *Optical Telescopes* at BIFR for the Astronomy and Astrophysics courses.

P. K. Mahesh is guiding two students in the final semester of the undergraduate course in Mechanical Engineering at BTL Institute of Technology, Bangalore. They are carrying out their final year projects at the Mechanical Design Section. This involves the modeling and finite element analysis of the mechanical structure of the 30 inch telescope at VBO, Kavalur. Two undergraduate students of Mechanical Engineering, one from Sree Sastha Institute of Engineering and Technology, Chennai and one from Priyadarshini Engineering College, Vaniyambadi, were also guided in a project titled *A study of Serrurier Truss.* An undergraduate student in Mechanical Engineering from National Institute of Technology, Durgapur underwent a short term course titled *A Study of Telescopes for Optical Astronomy* and a report on the same was prepared by the student.

A. Mangalam taught the following graduate courses: The full course on *Fluid Mechanics and Plasma Physics*for IIA/JAP, August – December 2008- thirty lectures, Forty five problems, conducted mid-term and final exams. Course followed the texts by Landau & Lifshitz and Kulsrud; *Astrophysical Concepts* for IIA/ I Phd–M Tech, the part on relativistic astrophysics, December 13 – 17, 2008, nine lectures, twenty problems, conducted final exam. The course followed the text by M. Harwit. *Statistical Physics* for IIA I PhD – Physics, Part 1, February – April 2009. Twenty four lectures, fifty problems. Course followed the texts by Pathria and Rief, gave projects, and conducted mid-term and finals. *A. Mangalam* also set the questions for the I PhD (Physics) course on *Classical Mechanics* and evaluated the answer scripts.

J. Murthy guided the following students: Anantha C. Pradhan (whole year) PhD Student working on *FUSE observations of the LMC*; Veena S. (whole year) PhD student at Calicut University on *Observations of Carbon absorption lines in the Interstellar Medium*; M. Y. Anand (March – September 2008) PhD student at Bangalore University: *IUE Observations of Interstellar Bubbles*; V. P. Singh & Mahindra (March – May, 2008) IIT(A) students. Project was *Detecting variability in real time observations*; Athira Nambiar (April – July 2008), BE student from the University of Calicut. *Gaussian fitting of spectral lines*; C. K. Lokesh & B. R. Sunil (April – July, 2008) BE students from the Global Institute of Technology, on *Planetary ephemerides for the web*; Rahul Munshi (April – July, 2008) B Sc student from IIT (Kharagpur): *Optics design for a UV spectrograph*; Paritosh Verma (December – January 2009) BE student from the Jaypee Institute of Engineering and Technology (MP), on *Spectral energy distribution for interstellar dust clouds*; Eight students from Jain College of Engineering working on a mechanical design for a UV spectrograph; Rahul Suresh (April 2008 – March 2009): BE student from NITK (Surathkal): *Galex observations in the Draco Nebula.*

Under the guidance of *K. N. Nagendra, M. Sampoorna*, successfully completed her PhD in 2008, *Nagendra* is serving as a guide to L. S. Anusha, a regular PhD student of IIA, from January 2008 on her PhD thesis. *Advanced Numerical Methods for Polarized Radiative Transfer: Astrophysical Applications.* He also Served as a research guide to H. N. Smitha under the "Summer Project Students programme – 2008". Title: *Polarization in Light Scattering on Atoms* Serving as a Research Guide to K. Sowmya under the "REAP Programme – 2008 of the Planetarium." Title: *Line Broadening Mechanisms of Astrophysical Interest*

G. Pandey taught the following JAP course: *Astronomical Techniques* (optical part) with B. E. Reddy (August – November 2008).

T. P. Prabhu is guiding S. Ramya on her PhD thesis entitled *Observational Study of Compact Dwarf and Low Luminosity Galaxies. T.P. Prabhu and G.C. Anupama* are guiding Amit Shukla on his PhD thesis entitled *Radiation Mechanism in Very High Energy Gamma Ray Sources. T. P. Prabhu* taught the following topics at the Summer School in Astronomy and Astrophysics, VBO, Kavalur, 15 – 22 May 2008: Variable Stars - extrinsic and intrinsic variability; Galactic Astronomy. He gave a talk on *Observational Facilities in India* at 100 hours of Astronomy, MPBIFR, Bangalore on 13 December 2008 (Saturday Batch) and 14 December 2008 (Sunday Batch).

K. P. Raju guided Kamalam Vanninathan, M. Sc. student, Christ College, Bangalore under the IIA Summer Project students' programme during May 15 – July 15, 2008 title: *Studies of Solar activity from Kodaikanal Ca-K data*

K. E. Rangarajan taught the course on *Radiative Processes* jointly with *R. T. Gangadhara* for the PhD students. *Rangarajan* has guided Parameswari from BITS jointly with Mr. *Thulasidharen* on a six month project on "Limb Tracker for KTT". Rangarajan

is guiding Ms. Usha Tejomoortula from CSUN for her MS thesis on *Infrared Helium and Hydrogen line formation in solar chromosphere* jointly with Debi Prasad Choudhary, CSUN. Rangarajan's PhD student K. Nagaraju submitted his thesis to the Mangalore university in July, 2008.

E. Reddy taught the following courses : IIA/JAP : Astronomical Techniques, Twelve lectures, from 18 August – 22 September, 2008; I P hd : *Data Mining and Analysis,* a course of ten lectures. He is guiding two PhD students : Bharat Kumar, topic : *Study of Li-rich K Giants,* and P. Ramya, topic : *Galaxy Formation: Role of Galactic Streams.*

S. K. Saha has guided an IRES student, Driss Takir, University of North Dakota, Grand Forks, ND during June 13 – August 7, 2008.

S. Sengupta taught Radiative Transfer and Stellar Atmospheres as a part of the first semester of IIA-CU integrated M Tech programme during November 2009. Malay Maiti, worked under the supervision of *S. Sengupta* for his thesis on *Theory and observation of brown dwarfs*, which he submitted in March 2009 to the Faculty of Science, Mangalore University. He has worked on observation of optical variability (in R and I band) from a few bright brown dwarfs.

P. Shastri supervised the PhD research of Veeresh Singh. She lectured at the 9th COSPAR Capacity-building Workshop, Kualalampur, June, 2008, on the topic of *Galaxies.* At this workshop, she led a mini-workshop on *Writing a Proposal for the Hubble Space Telescope*, and also supervised a student project titled *Correlation between NIR and radio core luminosity of FR-I Galaxies*, by Muhammad Qureshi, Qader Dorosti and Sudhanshu Barway. She organised the Second IIA-PennState Astrostatistics School, July, 2008, Vainu Bappu Observatory, and lectured on the topic *Challenges of Modern Empirical Astrophysics.*

C. Sivaram taught the following courses : JAP course (attended also by IIA PhD students) on *High Energy Astrophysics*, January – May, 2009 (20 lectures); Course on *General Relativity and Cosmology* given to Post Graduate students, Bangalore University, February – May, 2009 (20 lectures); Course on *Nuclear and Particle Physics* given to Integrated PhD students (IIA), January – May 2009; Advanced course in Astrobiology and Astrochemistry (to graduate students), BIFR, February – March, 2009; Course on Space and Rocket Dynamics, Intercollegiate course, St. Josephs College and ISRO (20 lectures); Several pedagogical lectures (about 25) given in the past one year on various topics in physics and astrophysics at various refresher courses, certificate courses at different colleges and institutes. Also chief guest and keynote speaker at a number of inaugural functions, like COSMOS-08, Christ College, October 24; Science and Technology Forum, M. S. Ramaiah Institute of Technology; Darwin Bicentennial, St. Josephs College, February, 28. C. Sivaram continued as Course Director, for the course on *Space and Rocket Dynamics* (inter-collegiate course conducted by St. Josephs College and ISRO) for the fourth consecutive year. Gave 15 lectures.

C. Stalin guided Shivinder Singh Takur, during May 2008 – June 2008, as part of the summer students programme of IIA, on the project, *Reverberation mapping of a low luminosity AGN.* He also gave two lectures on *Extragalactic Astronomy* to the 2008 batch of summer students of IIA, during May 2008, at VBO, Kavalur; Gave one lecture on *Active Galaxies* to the 2008 batch of IIA graduate students during October 2008 at IIA, Bangalore. He also visited Cochin University of Science and Technology to coordinate the IIA, PhD entrance examination, in December 2008.

N. Verma guided Erik J. Larson an IRES (International Research Experience for US Graduate Students Study Astronomy/Astrophysics in India) student, from the University of Colorado, US during July – August, 2008. The work on the process for Skyradiometer data was studied and analysed.

Lecture courses outside IIA

S. Chatterjee gave a set of eleven lectures on the topic of 'Optics and Inversion' at Udaipur Solar Observatory from 13–22 October 2008. He also taught a course at the Mohan Lal Sukhadia University, Udaipur on "Optical and Near IR studies of stars and galaxies", to the M.Sc. students who specialise in astronomy during 15th–20th January, 2009.
K. M. Hiremath taught a course on *Solar Physics* to M. Sc (Physics) students, as a guest Faculty at the Center for Post Graduate Studies of Sri Bhagawan Mahaveer Jain College, Jayanagar, Bangalore.

J. Murthy gave a Certificate course in *An Introduc-*

tion to Astronomy (15 lectures) at Christ University, October 2008 – January 2009; He also gave lectures the whole year at Birla Institute of Fundamental Research: Several talks on *Space Astronomy, UV Astronomy and the Interstellar Medium*; St. Joseph's College *Interstellar Medium and Space Astronomy*; Planetarium *Interstellar Medium, UV Astronomy*; *Diffuse Interstellar Radiation Field, Interstellar Medium, UV Astronomy* at Karnatak University, Dharwad (3 lectures): March 2 – 3, 2009. In June, 2008, he lectured on *UV Astronomy* at the COSPAR workshop in Malaysia.

K. B. Ramesh gave a specialized course on *Solar physics* to engineering and post-graduate students at the M. P. Birla Institute of Fundamental Research during February and March 2009. Ramesh also gave three lectures on *The Sun* and one lecture on *The Sun and the solar system in general astronomy* at the M. P. Birla Institute of Fundamental Research.

S. Sengupta taught the following courses : *Extrasolar Planets - These Wonderful Worlds* : September 12, 2008, Indian Institute of Technology, Kharagpur; *Extrasolar Planet* : September 27 2008, M. P. Birla Institute of Fundamental Research, Bangalore; *Extrasolar Planets and their Climate* : October 03, 2008, Indian Institute of Science, Bangalore; *In search of Life Outside Solar System* : November 07, 2008, Calcutta University, Kolkata; *Extrasolar Planet* : December 07 2008, M. P. Birla Institute of Fundamental Research, Bangalore.

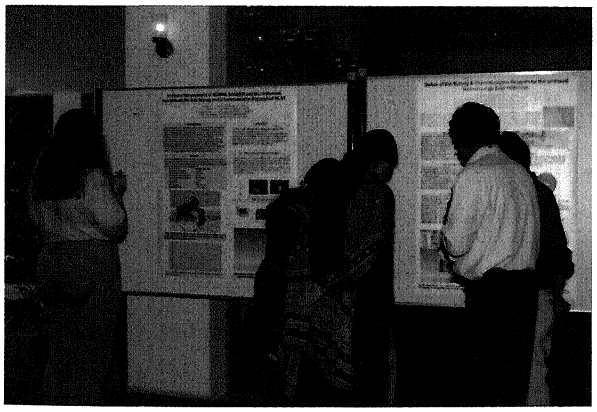
K. Sundara Raman delivered a series of lectures, as an adjunct Faculty of the Mother Teresa University, Kodaikanal, for the II M.Sc Astrophysics and M.Phil students, during August – October, 2008 and also functioned as the external examiner and conducted the viva voce and practical examinations for their I & II M.Sc physics students, during April and November 2008; As chief examiner he evaluated and conducted the viva voce examination of 10 M. Phil physics theses (3 in Astrophysics and 7 in Material Science & Nanotechnology) of Mother Teresa University, Kodaikanal during April – May, 2008; He also guided the following students : 4 M. Sc. (Physics) and 8 B. Sc. (Physics) students of Mother Teresa Womens University, Kodaikanal in their dissertation work from November 2008 to February 2009; 12th Grade Student of Kodaikanal International School, for a month's project work on Solar Physics; Coordinated with the other field stations of IIA, University of Madras and sent the M.Sc. and M. Phil students of Mother Teresa University, Kodaikanal to the various centers for doing their dissertation work.

Chapter 4

Scientific Conferences, Workshops & Lectures at IIA

4.1 In-House Science Meeting

IIA's in-house science meeting is now a regular annual feature. This year it took place on the 15 & 16th April, 2008. The meeting was an occasion for IIA's scientists to deliberate together on current research in IIA's varied research areas, which were represented in over 25 oral presentations. Several of the talks were given by IIA's PhD students and post-doctoral fellows. There were also about 20 poster presentations.



The poster session of the IIA In-House Science Meeting

4.2 National Meeting on the 2009 Solar Eclipse

A one-day national meeting was held on the "2009 Total Solar Eclipse" on June 23, 2008 at Indian Institute of Astrophysics, Bangalore. On 2009 July 22, the total eclipse of the Sun will be visible from within a narrow corridor that traverses half of the Earth, which includes most of eastern Asia, and the Pacific ocean. The total solar eclipse of 22 July, 2009 will be the longest eclipse of the 21st Century being 6 minutes 38 seconds at the point of maximum eclipse.

4.3 Meeting on India's Participation in GSMTs

Extremely large telescopes, with effective apertures of more than 20 metres, are considered to be the next big step in ground-based astronomy. Generically called Giant Segmented Mirror Telescopes or GSMTs, they will vastly improve our knowledge of stars, planets and galaxies and address more sharply questions regarding the origin and formation of planets around other stars, the first objects in the Universe, and the nature and distribution of dark matter and dark energy that dominate the Universe. Two US-led groups and ESO with its user community of European astronomers have been independently planning three large ground-based telescopes with capabilities in optical and the infrared, which may usher in the new era in astronomy in the next decade and a half. The price tag on each instrument is a billion US dollars or more and none of the three groups have so far raised enough funds to fulfill their needs. Each project will need to have several partners and the lead agencies are in the process of finding them in countries that have serious professional interest and manpower in astronomy. This has naturally led to the possibility of India joining one of them at a level of 10% to 15% participation. A one-day national meeting was organized in IIA on September 27, 2008 to discuss the Indian science interests and possible modes of Indian participation in one of the GSMT projects.

The meeting was attended by representatives of

all the major astronomy research institutions and the universities, where there is sufficient interest and activity in astronomy, namely, Utkal, Osmania, Delhi, SRTM University, Nanded, Pandit Ravishankar Shukla University, Raipur and Assam University, Silchar. There were a total of 75 participants.

Participants at the National Meeting on India's participation in GSMT projects

The first session started with the opening remarks by Professor Siraj Hasan, who gave a historical perspective on the development of optical astronomy in IIA. He said as early as 1978, Dr Vainu Bappu was already thinking of the next big step after the 90-inch telescope and had said that India should go for a 6-metre class telescope. Professor Hasan also recalled IIAs quest for a large telescope that started in 1989 and led to the proposal, in the 1990s, of setting up a national large optical/IR telescope in the trans-Himalayan region. Although a 2-m telescope was set up in Hanle, the large telescope project failed to take off. Professor Hasan felt strongly that the astronomy community had waited long and it must now seize the opportunity to participate in one of the GSMT projects, which seemed to have come at the right time. Professor Ram Sagar endorsed this view and gave compelling reasons why we must actively participate in the venture. He mentioned areas where the need to have a very large optical facility is being felt ever so strongly. Professor Naresh Dadhich spoke on behalf of the astronomers in IUCAA, how they are very keen on this participation. He said if a challenge were thrown, our astronomers would rise to match it. He felt that the initiative to participate has to be a national one and should not come from any one institution.

B. Eswar Reddy (IIA) and R. Srianand (IUCAA) made presentations on the status of the three GSMT projects and their technical capabilities. While Reddy gave a comparative budget analysis of the American projects, the Giant Magellan Telescope (GMT) and the 30-metre Telescope (TMT), and shared with the audience some of the official communications received from the GMT and TMT consortia inviting India to join in a partnership, Srianand argued for a re-orientation in our thinking and way of working when these big telescopes become available to us. He pointed out that 16 nights of observations at a telescope like SALT are equivalent to a year of observations with a 2-m class telescope. A 30-m telescope is even more different as the science expected from it is entirely different from what is expected of even a 8-m telescope. According to Srianand, it is not just a matter of scaling up and the Indian community should prepare itself seriously to measure up to the potential offered by this new class of machines.

In the second session, the specific scientific interests of the Indian astronomers were discussed by G. C. Anupama (IIA), Swara Ravindranath (IUCAA) Pushpa Khare (Utkal University), D. K. Ojha (TIFR) and A. C. Gupta (ARIES).

In the third session, held after lunch, A. K. Saxena (IIA) gave a short presentation on the capabilities of the Indian industries. Ajit Kembhavi (IUCAA) talked about the need for resource development including human resources. If India did indeed decide to participate in one of the GSMT projects, there is every likelihood that a large number of opportunities in software would open up and Indians should be able to seize such opportunities, given the strong software capabilities present in the country. B. R. Prasad (IIA) spoke of IIAs synergy with the Indian industries in developing and delivering many projects. Uday Shankar (RRI) summarised various international partnerships his institution has already successfully participated in, e.g., the RRI-MWA and RRI-GBT partnerships. He was confident that in certain areas like the possible application of radio imaging technology to adaptive optics, building control systems and hardware and in handling astronomical data centres, RRI could contribute substantially.

The last session was a moderated discussion chaired by Professor Hasan. Issues like manpower and its projected development, the need for training students in using 8 to 10 metre class telescopes to prepare to handle the GSMTs and accelerated growth of astronomy in the Indian universities were discussed threadbare. The present initiatives taken by IIA and IUCAA in training students in astronomy and astrophysics were described. Several other useful suggestions were made. Ranjan Gupta (IUCAA), the current Secretary of the Astronomical Society of

India, suggested that a session should be organized on the GSMT project proposal during the forthcoming meeting of the Society. A word of caution was added by Professor Harish Bhatt saying that the existing astronomical facilities in the country should by no means be neglected.

Professor T. Padmanabhan gave the concluding remarks. It was clear from the deliberations at the meeting that there is a consensus among the Indian astronomers with regard to the participation in one of the GSMT projects, as the community requires access to a cutting-edge facility. To proceed further several tasks need to be undertaken in parallel. A serious dialogue has to start with the funding agencies. The astronomy institutes need to prepare a proposal document summarising the discussions at the meeting. Much more information in much greater detail on all three GSMT projects need to be obtained and a serious analysis on the relative merits and demerits of each has to be made before choosing one of them for the Indian needs. It was also stated that the funding authorities might insist on participation in kind, e.g., in software and/or instrument development, in addition to payment in cash, and the modalities would then have to be worked out with the concerned lead agencies of the projects.

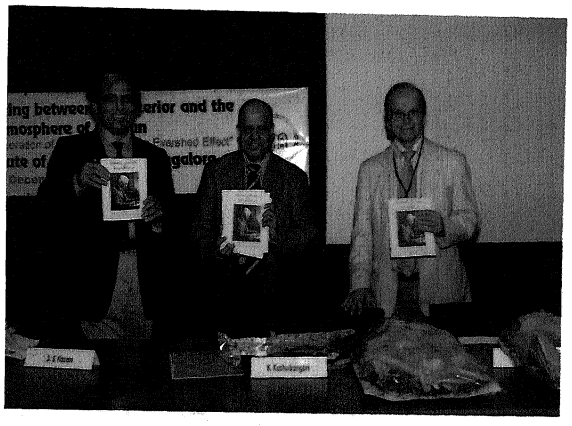
The meeting concluded with a vote of thanks proposed by the Convener, B. Eswar Reddy.

(D. C. V. Mallik)

4.4 Centenary Commemoration of the Discovery of the Evershed Effect

An international conference on 'Magnetic Coupling between the Interior and the Atmosphere of the Sun' was organized by IIA, during 2 – 6 December, 2008, at its Bangalore campus, to commemorate 100 years since the discovery of Evershed effect. This meeting attracted a large number of leading experts in the study of the Sun, from all over the world, and provided an excellent forum for them, thanks to the smooth organizational support from the LOC and administrative staff of the Institute, to present and discuss the latest results encompassing all aspects of solar magnetism.

The inaugural session of the meeting, in the morning of 2nd December, started with a welcome address by the Director of IIA, Siraj Hasan, who gave a historical account of research at the Kodaikanal Solar Observatory and the life and work of John Evershed



Professor Siraj Hasan, Dr. K. Kasturirangan & Professor Eric Priest release a brochure brought out by IIA on 'John Evershed and Solar Physics at the Kodaikanal Observatory' at the inauguration of the Evershed effect commemoration meeting

at Kodaikanal. He also summarised the current research activities and major projects planned for the near future in solar physics at IIA. Renowned solar physicist Eric Priest from the University of St. Andrews, Scotland, then made opening remarks followed by the formal inauguration and address by the Chair, Governing Council of IIA, K. Kasturirangan. He also released a brochure on 'John Evershed and Solar Physics at the Kodaikanal Observatory' brought out by the IIA.

The scientific programme consisted of six oral sessions spread over the four days of the meeting schedule. Posters, about 80, grouped similarly into six topics were on display throughout the meeting. The oral sessions had 33 invited reviews and talks, and 20 contributed talks. There were about 120 participants, including about 58 from abroad.

The first day's scientific sessions covered magnetic field generation in the solar interior, magnetoconvection and transport, and local helioseismology of sunspots and associated structures. Current ideas on the transport of angular momentum across the solar tachocline, state of the art numerical simulations of interior convection, rotation and dynamo processes as well as predictions of solar cycles based on mean-field kinematic dynamo models were presented. The current state of affairs in the subject of sunspot seismology, and the problems and issues that need to be tackled were part of the discussions in the last session of the first day.

New techniques to measure magnetic fields in the weak field small-scale regime, where Zeeman diagnostics fail, were pointed to and discussed on. Ad-

vances in polarized radiation diagnostics towards measuring field strengths in the chromosphere and corona were discussed. Various new instruments, recently commissioned as well as those planned, including the THEMIS facility in France, SHAZAM instrument being developed in the USA for the Dunn Solar Telescope and the Swedish Solar Telescope, and capabilities of back-end instruments for magnetic field measurements being developed for MAST (Multi-Aperture Solar Telescope, Udaipur Solar Observatory) and that being planned for the NLST (National Large Solar Telescope, IIA) were presented and discussed. Theoretical predictions for the probability distribution functions for both vertical and horizontal small-scale magnetic fields were presented. The agreement of such predictions with measurements using high-resolution polarimetry from space on Hinode (a Japanese-USA collaboration) was suggested to reflect the action of local dynamo in maintaining the small-scale fields.

Study of the dynamics of emerging magnetic flux regions has received a tremendous boost from excellent data provided by instruments on-board Hinode. Statistical analyses of such data were presented by Hinode science experts from Japan, with highlights on transport of magnetic helicity into the corona by the twisting motions driven by sub-surface dynamics of flux ropes.

The last session on day 2 was on 'Sunspots and Active Regions', which continued on to the next day. Different theoretical models on the interior structure and dynamics of sunspots were critically assessed in the light of various new high-resolution surface observations. Association between the thermal and magnetic signatures in the penumbral regions were critically examined, with a fine summary of current understanding of these features. The Wilson effect and physics of Wilson depressions were the subject of a research effort carried out using a long time base white light image data from the Kodaikanal Observatory, and the presented Results received critical assessment from the assembled experts. Numerical modelling of wave phenomena has seen rapid advances in recent years and the key results that have emerged were part of an elegant presentation. Continuation of discussions on 'Sunspots and Active Regions' on day three focussed on new results from very high-resolution observations using Hinode, including Doppler images of the Evershed flow structures.

The nature of heating processes in the corona, especially the dissipation of magnetic energy into heat observed as EUV and soft X-ray emission, as well as the plasma radio emission at low-frequency, is the subject of numerous models invoking either steady or impulsive processes. Results, again based on Hinode data, that provide support for the concept of multistranded nanoflare impulsive processes were presented. On the issues of heating the chromosphere and transition region, the latest Hinode observations that reveal fine dynamic fibrils, and spicules with heights of about 500 km and velocities of 50 – 150 km s^{-1}, together with high-speed upflows at the feet of coronal loops were presented and discussed. There were also reports on the recently developed 3D codes that follow flux emergence into a pre-existing field, and the development of loops and spicules.

The last day's deliberations focussed on eruptive phenomena: flares and coronal mass ejections (CME's). Theoretical and numerical models, as well as recent empirical results, especially on the energetics and helicity accumulation, formed the major part of the discussions. Results on waves and turbulence in the solar wind, based on continuing radio observations of interplanetary scintillation, were presented with significant inferences on the presence of Alfvén and ion cyclotron waves at distances of 50 $R_\odot$. Plans on in situ measurements of the solar wind flux on and near the surface of the Moon by the SWIM mass spectrometer on the recent Indian lunar mission Chandrayaan-1 were talked about.

The last session of the meeting focussed on Sun as a star, and on magnetic activity phenomena in distant stars. Comparisons of Sun in X-rays, with data from ROSAT mission on other main sequence stars, were made. The Sun is shown to be a relatively weak X-ray source but stellar flares are common on more active stars, ranging from fully convective late-M dwarfs to massive post-main sequence giants. Extensive data sets on several proxies of magnetic activity, like the Ca II emission and FIP effect, have been accumulated and the potential to study detailed aspects of solar-stellar connections were pointed to with discussions on representative new results. Quoting Nigel Weiss, who gave the 'Conference Summary & Perspective', 'the most striking impression given by the papers in this conference is of the enormous wealth of new observations that have been generated within the last fifteen years, both from space - with Yohkoh, SOHO and most excitingly with Hinode and also from the ground - most notably with the Swedish Solar Telescope and the upgraded Dunn Solar Telescope'. An excursion to the Kodaikanal Solar Observatory, about 350 km from Bangalore, followed the closing of the conference in the evening of the 5 December.

(S. P. Rajaguru)

4.5 Recent Advances in Spectroscopy

Spectroscopy is the basic tool employed in astronomy to derive physical parameters, like temperature, density, chemical composition, and velocity and magnetic fields, that give insights into the physical processes that are operative in the celestial objects and interstellar medium. Some of these processes can be studied by high resolution spectroscopy in the X-ray, UV and optical spectral regions. The atomic and molecular spectroscopy plays a key role in understanding the above mentioned processes. For example, the carbon bearing molecules, such as polycyclic aromatic hydrocarbons (PAHs), are now thought to be widespread in the interstellar medium in their neutral and ionized forms. Identifying the carriers responsible for several observed interstellar bands will allow us to derive important information on cosmic elemental abundance as well as on the physical conditions reigning in specific interstellar environments. The identifications of these carriers are the key for a correct understanding of the energetic mechanisms that govern the origin and evolution of the interstellar medium.

A multi-disciplinary approach is essential to address the complex issues involved in interpreting the data and understanding the physical conditions prevalent in the stellar and interstellar medium. It is with this idea that the international conference on "Recent Advances in Spectroscopy: Theoretical, Astrophysical, and Experimental Perspectives" was organized at Kodaikanal from January 28 – 31, 2009. Several experts in the areas of theoretical and experimental atomic physics, and observational astrophysics were brought together in one platform.

The conference began with the welcome note and opening remarks and had 12 sessions spread over three and a half days. The first two sessions were devoted to the general aspects of Atomic and Molecular spectroscopy, and the next to the experimental aspects of Atomic and Molecular Spectroscopy. These were followed by three sessions on theoretical aspects of spectroscopy. One session was devoted to line formation in stellar atmospheres. There were two sessions on observations and analysis in connection with Solar spectroscopy and three sessions on similar topics connected with Stellar spectroscopy.

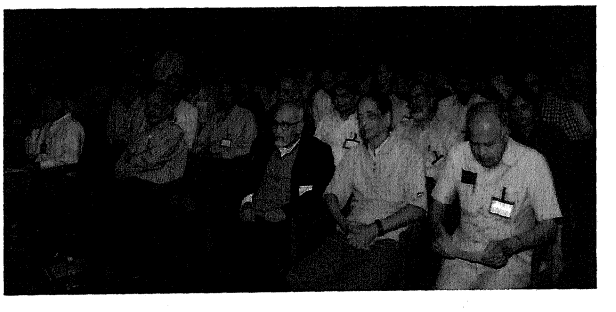
The topics covered during the conference was summarized by T. P. Prabhu, followed by a concluding vote of thanks by R. K. Chaudhuri.

(Rajat K. Chaudhuri & M. V. Mekkaden)

Participants at the meeting on *Recent Advances in Spectroscopy*, Kodaikanal

4.6 27th meeting of the Astronomical Society of India

IIA hosted the meeting of the Astronomical Society of India after a gap of 23 years. The meeting was held in the IIA campus, and had over 250 participants. The Presidential address by Jitendra Nath Goswami was followed by the award ceremony of the Vainu Bappu Memorial Gold Medal. The awardee, Banibrata Mukhopadhyay of IISc delivered the Vainu Bappu award lecture, entitled "Measuring Spin of Black holes from their QPOs: A Test of General Relativity."



Participants at the 27th meeting of the Astronomical Soceity of India held at IIA.

The special scientific features of the meeting were two mini-symposia, "The Dynamic Sun and Star – formation History". There were 17 invited scientific talks on solar, stellar, Galactic and extragalactic astrophysics, and over 160 poster presentations. Specific time of 3 hours was allotted for poster-viewing and interactions, besides which five rapporteurs summarised the posters in the plenary session. There

were six talks in the customary session for PhD theses summaries. There was a session entitled "New Initiatives", which included talks describing new astronomy and data facilities in the country, as well as one on the outreach initiatives by Vigyan Prasar of DST.

Professor Jiten Goswami, ASI President and Dr. Ranjan Gupta, ASI secretary, at the 27th meeting of the Astronomical Soceity of India held at IIA.

Jayant Narlikar delivered an evening lecture titled "How Astronomy has Contributed to Enrichment and Survival of Human Societies" to a packed auditorium that included members of the public. A notable feature of the ASI was a late-evening reminiscences session, in which the past presidents of ASI dwelt on the contributions by the late Krishna Damodar Abhyankar, his initiation of the formation of the ASI and later, his persistent efforts to sustain it.

There was a parallel meeting of the "Forum for Resource Sharing in Astronomy", in which librarians of IIA, RRI, TIFR, IUCAA, NCRA and ARIES discussed digitisation projects, and implementation of open access repositories. In addition, IIA organized a digital exhibit of astronomical photography by amateur astronomers, and a play on Galileo.

G. C. Anupama was convenor of the local organising committee, which received excellent support from the administrative, computer support and library staff of IIA. In addition to IIA, the meeting was sponsored by PRL, IUCAA, ARIES, ISRO, TIFR, RRI and HRI, and also received support from Allied Publications, Cambridge University Press and Elsevier Science.

4.7 Lectures at IIA

Colloquia

08 April 2008
Attila Grandpierre
Konkoly Observatory, Budapest, Hungary
Dynamics in the Solar Core

22 April 2008
Simon Jeffery
Armagh Observatory
Northern Ireland
FG Sagittae - Chemical Evolution Over Half a Century: Was the Thermal Pulse Late or Very Late ?

29 April 2008
Amanda Karakas
Mt Stromlo Observatory, Canberra, Australia
Nucleosynthesis in Asymptotic Giant Branch Stars

13 May 2008
Katharina Lodders
Washington University, St. Louis, USA
Chemistry in the Atmospheres of Brown Dwarfs and Exoplanets

24 June 2008
John Hutchings
Herzberg Institute of Astrophysics, Victoria, Canada
Quasars in SDSS and GALEX Databases

08 July 2008
Shrinivas Kulkarni
California Institute of Technology, Pasadena, USA
The Space Interferometer Mission: Parallaxes, Planets and More

12 August 2008
Monica Valluri
University of Michigan, Ann Arbor, USA
The Dynamical Evolution of Dark Matter Halos

26 August 2008
Dipak Munshi
Institute of Astronomy, Cambridge, UK
Finger-printing the Universe : Error in Error-bars

October 14
Shravan Hanasoge
Stanford University, Stanford, CA, USA
Developments in the Helioseismic Imaging of the Deep Solar Interior and Sunspot Structure

04 November 2008
Jayaram Chengalur
National Centre for Radio Astrophysics, TIFR, Pune
FIGGS: The Faint Irregular Galaxy GMRT Survey

11 November 2008
Inwoo Han
Korea Astronomy and Space Science Institute
Daejeon, Korea
Searching for Exoplanets

18 November 2008
Hamed Moradi
Monash University, Melbourne, Australia
The Role of Near-Surface Magnetic Fields in Sunspot Seismology

25 November 2008
Paola di Matteo
Observatory of Paris, Meudon, France
Evolution of Galaxies in Pairs: Learning from Simulations

16 December 2008
Alain Omont
Institut d'Astrophysique de Paris, France
High Redshift Ultra-Luminous Far-IR Galaxies
(Submillimeter Galaxies) in Spitzer Surveys

23 December 2008
Jan Olof Stenflo
Swiss Federal Institute of Technology (ETH), Zurich, Switzerland
The Second Solar Spectrum

06 January 2009
Rahul Shetty
Harvard-Smithsonian Center for Astrophysics
Cambridge, USA
Spiral Arm Structure and Cloud Formation in Disk Galaxies

13 January 2009
Dhrubaditya Mitra
Queen Mary College, University of London
London, UK
Understanding the Solar Dynamo : Some Recent Results

20 January 2009
Dimitar Sasselov
Harvard-Smithsonian Center for Astrophysics
Cambridge, USA
Super-Earth Planets: Exploring Environments with Habitable Potential

27 January 2009
Karen J. Meech
University of Hawaii, Honolulu, USA
Origin of Earths Water

10 February 2009
Robert J. Rutten
Sterrekundig Instituut Utrecht, The Netherlands
Observing, Interpreting, and Using the Solar Chromosphere

03 March 2009
Varsha Chitnis
Tata Institute of Fundamental Research, Mumbai
The Universe at Very High Gamma-Ray Energies

31 March 2009
David Pérez-Suárez
Armagh Observatory, College Hill, Northern Ireland
Structure and Evolution of Coronal Bright Points in the Sun

Seminars

10 April 2008
Dirk Soltau
Kiepenheuer-Institut fr Sonnenphysik, Freiburg, Germany
Adaptive Optics at the German Solar Telescopes on Tenerife

15 May 2008
Bruce Fegley
Washington University, St. Louis, USA
Atmospheric Chemistry during the Accretion of Earth-like Exoplanets

12 June 2008
Ritaban Chatterjee
Boston University, Boston, USA
Correlated Multi-Frequency Time Variability in the Blazar 3C 279

26 June 2008
Chiranjib Sur
Ohio State University, Columbus, USA
Fe K-lines : Applications to X-ray and Gamma-ray Astronomy

19 June 2008
A. R. Ganesan
Indian Institute of Technology, Chennai
Optical Wavefront Sensing and Control for Adaptive Optics Applications

07 July 2008
Claudio Ricci
Data Centre for Astrophysics, Geneva University, Switzerland
The Integral View on AGN

16 July 2008
S. P. Bagare
Indian Institute of Astrophysics
Status Report of NLST

17 July 2008
Benjamin Trakhtenbrot
Tel-Aviv University, Ramat Aviv, Israel
Measuring the Mass and Accretion-rate of Super-Massive Black Holes in AGN through Cosmic Epochs

01 August 2008
Ashish Mahabal
California Institute of Technology, Pasadena, USA
Transient Detection and Classification

28 August 2008
Sabyasachi Chatterjee
Indian Institute of Astrophysics
What is Graphite? Its Formation, Morphology and Extinction

18 September 2008
Manas Mukherjee
Indian Association for the Cultivation of Science, Kolkata
Particle Trap: A Universal Tool for Atomic and Molecular Physics Experiments

03 October 2008
Patrick McCarthy
Carnegie Observatories, Pasadena, USA
The Giant Magellan Telescope Project

08 October 2008
Tapas K Das
Harish Chandra Research Institute, Allahabad
Astrophysical Accretion as an Analogue Gravity Phenomenon

31 October 2008
Mausumi Dikpati
National Center for Atmospheric Research
Boulder, USA
Simulating Solar Climate: Opportunities and Challenges

19 November 2008
Tanya A. Ryabchikova
Institute of Astronomy
Russian Academy of Sciences
Moscow, Russia
Chemical Structure of the Atmospheres of Ap Stars

20 November 2008
Mikhail E. Sachkov
Institute of Astronomy
Russian Academy of Sciences
Moscow, Russia
The World Space Observatory: An Ultraviolet Mission for the Next Decade

21 November 2008
Tanya A. Ryabchikova
Institute of Astronomy
Russian Academy of Sciences
Moscow, Russia
The Vienna Atomic Line Database and its use in Stellar Atmosphere Structure and Abundance Analysis

24 November 2008
C. S. Stalin
Indian Institute of Astrophysics
Estimation of H0 through Monitoring of Lensed Quasars

27 November 2008
Sami Dib
Service d'Astrophysique, CEA, Saclay, France
Formation and Properties of Dense Cores in Molecular Clouds

17 December 2008
Bhimsen Shivamoggi
University of Central Florida, Orlando, USA
Driven Magnetic Field Reconnection in Hall MHD

07 January 2009
Vikram Soni
National Physical Laboratory, New Delhi
A Solution to the Puzzle of Magnetars

29 January 2009
Jaroslaw Kijak
Institute of Astronomy, University of Zielona Gra, Poland
Turn-over in Pulsar Radio Spectra

05 February 2009
Wolfgang Kalkofen
Harvard-Smithsonian Center
for Astrophysics, Cambridge, USA
The Structure of the Sun, from the Deep Interior to the Outer Layers: What we believe we know about it

30 March 2009
Mukul Kundu
University of Maryland, College Park, USA
Recent Progress in Solar Radio Physics in Microwaves

Special Lectures

30 May 2008
Roger Blandford
Stanford University, Menlo Park, USA
New Opportunities with Gravitational Lenses

11 August 2008
C. N. R. Rao
Jawaharlal Nehru Centre for Advanced Scientific Research and Indian Institute of Science, Bangalore
Founder's Day Lecture : Doing Science in India: Personal Reflections

12 August 2008
Claude Nicollier
EPFL STI, Lausanne,
Switzerland
My Experiences in Space

06 October 2008
Tapas K. Das
Harish Chandra Research Institute, Allahabad
Black Holes in your Bathtub

14 November 2008
Phil Charles
South African Astronomical Observatory
Cape Town, South Africa
Time Domain Astrophysics with the Southern African Large Telescope

15 January 2009
B. S. Chandrasekhar
Walther-Meiner-Institut, Garching, Germany
Low Temperature Physics and Physicists Six Decades Ago

23 January 2009
Anil Pradhan
Ohio State University, Columbus, USA
From Astrophysics to Cancer Theranostics via Nanotechnology

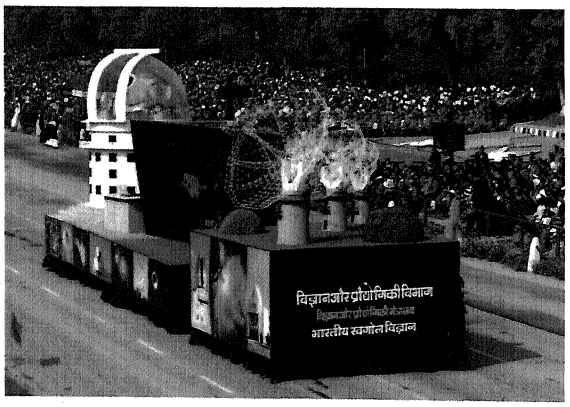
Chapter 5

Outreach Programmes

IIA has expanded its outreach activities on many fronts. These activities received a fillip from stepping into the International Year of Astronomy.

5.1 Astronomy Tableau at the Republic Day Parade

On behalf of the Department of Science and Technology, IIA designed and presented a tableau on astronomy at the Republic Day Parade in New Delhi, on the 26th January, 2009. The current Indian Astronomy scene was exemplified in the theme of the tableau by several exhibits. A model of a radio interferometric telescope represented the Giant Metrewave Radio Telescope operated by the Tata Institute of Fundamental Research in Maharashtra, and a model of an optical telescope represented IIAs Vainu Bappu telescope. In addition, the beauty of the cosmos was displayed through a running slide show of astronomical images on large digital screens, and also present were professional astronomers shown interacting with people representing the ever-curious public.



The Astronomy float at the Republic Day parade, New Delhi, 26th January, 2009.

5.2 Capacity Building in Schools

IIA continues its extension programme with the Government High School, Madivaala, begun in 2008. IIA scientists have helped the teachers and students undertake hands-on experiments on a long-term basis.

(IYA team)

IIA partnered with the National Institute for Advanced Studies (NIAS) to enhance extra-curricular astronomy programmes in schools. NIAS provided grants to a few schools for procurement and installation of telescopes, and IIA provided the technical support to install the telescopes and domes. Nirmala Rani Girls High School, Malleswaram, and Poornima Learning Centre, Yelahanka, now have a 14inch and a 8inch Celestron telescope respectively, complete with a 3m-diameter dome.

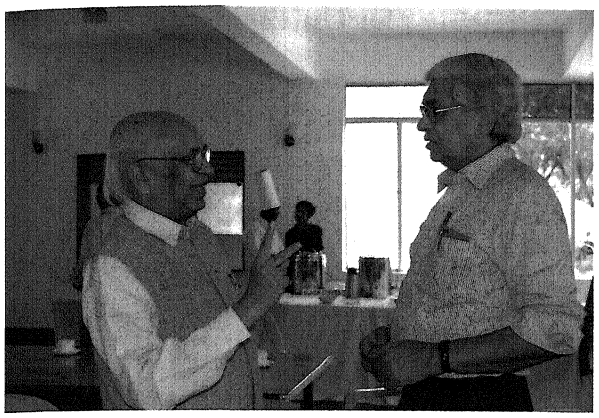
(S. P. Bagare, J. P. A. Samson & M. B. Rajani)*

5.3 Workshops & Conferences

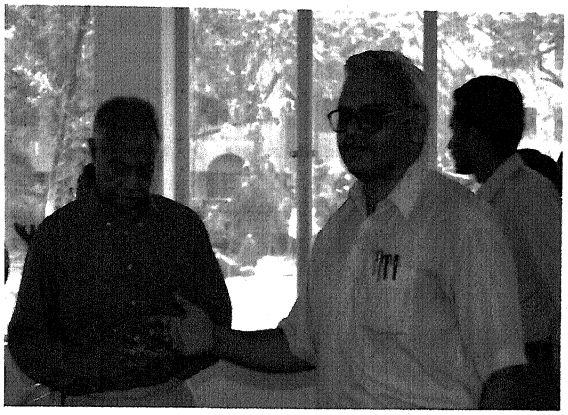
Universalising the Universe

As a preparation for the forthcoming International Year of Astronomy in 2009 (IYA), IIA organized a one-day seminar on April 4, 2008, titled, *Universalising the Universe*. It brought together on a single platform, scientists, teachers, students, social scientists, science popularisers and cultural activists to deliberate on IYAs central theme, that to look into the sky with a telescope, provides an important opportunity to present science as a medium of international co-operation for peace, progress and global understanding.

Emphasizing the above aim, first announced by the IAU and then endorsed by the UN General As-



B.V. Subbarayappa and Vinod Gaur at the *Universalising the Universe* workshop.



Theatre personality Vijay Padaki with Sabyasachi Chatterjee at the *Universalising the Universe* workshop.

sembly, Professor Vinod Gaur (IIA) in his inaugural address said that the sky is a universal laboratory, from where one can learn mechanics, electromagnetism and relativity, thus progressing from the realm of wonder to that of knowledge. Concerning the democratic nature of this experience, Professor Siraj Hasan, Director, said that in the spirit of IYA's objectives, large number of people must be drawn into the process and larger the mobilisation, larger is the impact. He observed that as Galileo's life exemplifies, this event could be considered as a step to challenge obscurantism by scientific rationality.

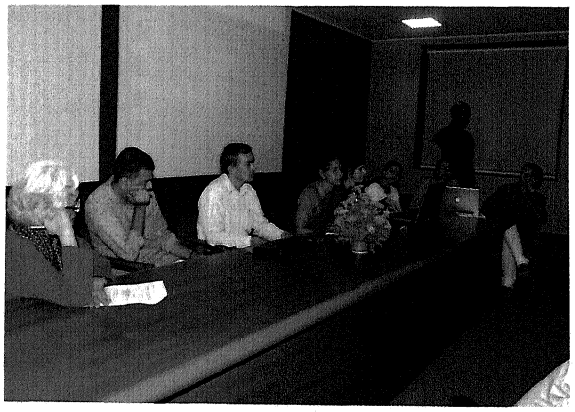
A series of talks on the theme "The sky as the universal laboratory" was presented with practical examples from naked eye astronomy (H.R. Ramakrishna Rao, formerly Christ College), astronomy with the sun (Jagdev Singh, IIA), night-sky observations with inexpensive $2''$ – $12''$ telescopes (T. P. Prabhu, IIA), and pictures obtained from space (J. Murthy, IIA). It was noted that while a small $2''$ telescope (to be called Galileoscope, as suggested by the IAU) could act as the first instrument to initiate the uninitiated, larger telescopes in the country should be made accessible to the experienced amateur and the data from space could act as a resource that students and amateurs could exploit.

Science writing forms an important part of science popularisation. P. R. Vishwanath (IIA) and Biman Nath (RRI) noted that a scientist is placed with a great social responsibility and science writing gives the scientist a method to discharge this commitment. Vijay Padaki, of the 'Bangalore Little Theatre' recorded that science can form an important theme for drama, as science gives a new window to understand the history of ideas.

B. S. Shylaja (Nehru Planetarium, Bangalore) noted that though astronomy is included in school and college syllabi, there is no introduction to practical observations. She narrated her experiences in introducing observational astronomy to several groups of students, using inexpensive equipment and simple mathematical analyses. A. Hemavathi (Pondicherry Science Forum) recalled that many a popular science organisation had emerged in response to the popular demand for mass viewing of the Halley's comet. She recalled that large numbers do come out, surmounting social obscurantism for viewing events such as eclipses and the Venus transit. K. Pappootty of the Kerala Shastra Sahithya Parishat observed that the question of astrology crops up in many a popular talk on astronomy, and that the history of astronomy and astrology forms an important starting point in any dialogue on scientific temper. M. Blesson, a PhD student from IIA, showed how modern audiovisual techniques can help popularise astronomy, and related the efforts in making a short film on the occasion of the International Year of Physics. Ajith Padmanabhan, an M.Sc. student form the Loyola College, Chennai shared the experiences of his group students in popularising astronomy among slum children and said that an inexpensive Galileoscope would greatly benefit this effort.

Democracy and equality being inseparable from scientific rationality, the IAU has declared "She is an astronomer" as a cornerstone activity for the IYA 2009. In a panel discussion with the same title speakers (Prajval Shastri, Vasundhara Raju, Neeharika Verma, Ramya S., B. R. Prasad, Prasad Subramanian, Firoza K. Sutaria) observed that gender inequity does continue in scientific institutions since natural scientists are reluctant to examine the role of societal forces in science, and are resistant to change.

They noted that this operates with subtlety which makes the phenomenon often inconspicuous. In their childhood, girls are not encouraged to take up science and low expectations lead to low results. Even in academia, it is often not recognised that women take science for their passion for it and it is the woman who moves out of science to keep the family intact. While this phenomenon operates at all levels, the panelists felt, science popularisation can help to change the social mindset and structural changes like removal of the age restriction at recruitment and filling up vacancies at all levels, are urgently needed.



The 'She is an Astronomer' panel discussion, chaired by Devaki Jain, at the *Universalising the Universe* workshop.

The meet discussed in its last session, the steps to link the unlinked (Vivek Monteiro, Nav Nirmiti and T. V. Venkateswaran, Vigyan Prasar) by which scientific institutions and popular science organisations can work together for IYA. They felt that with a viable programme it would be possible to reach a million people. It was suggested that a long-term project like a terra lab in every terrace can be a proposal that can begin as a part of IYA 2009 and continue even afterwards.

The sessions were chaired by B. V. Subbarayappa, H. C. Bhatt, Devaki Jain, K. Vasu and V. K. Gaur. Six posters from different groups were on display. The participants expressed the urge to work towards IYAs motto, 'Astronomy for All' and it was decided that the various groups would hold workshops throughout the year.

(IYA team)

Universalising the Universe II

The first *Universalising the Universe* workshop was a catalyzing event for many preparatory activities of the IYA 2009. Many science popularization groups from the southern states, who took part in the above meeting began their own state level meets almost immediately afterwards and convened an All India materials preparation workshop in Pondicherry, on the 6th and 7th September, 2008, in partnership with IIA. Attended by 60 delegates from Pondicherry, Tamil Nadu, Karnataka, Kerala, Andhra Pradesh, Maharashtra, Orissa, Jharkhand, West Bengal, Hary ana and Madhya Pradesh, many of whom were resource persons in astronomy in their respective organizations.

Vivek Monteiro of Navnirmiti, Mumbai, demonstrating Sun observation kits at the Pondicherry Workshop *Universalising the Universe II.*

Professor J.A.K.Tareen, vice-Chancellor of the Pondicherry University, who delivered the inaugural address, offered the university's help in future activities related to the IYA, and also said that the university would be interested to set up a museum and an observatory, for teaching and public outreach. IIA's scientists, S. Chatterjee, C. Muthumariappan and M. Safonova participated from IIA.

(IYA team)

IYA Workshop at the All-India Peoples' Science Congress, Ranchi

As part of its run-up activities to the IYA09, IIA co-organised a parallel session on IYA09 in the 12th All-India Peoples Science Congress at Ranchi, on the 20th December, 2008. About 600 delegates from all

over the country and about 2000 participants from Jharkhand, including scientists, educationists and science popularisers, participated in the conference. In the IYA09 session, Sabyasachi Chatterjee gave a talk on "Galileo's Revolution and the Significance of IYA", and Prajval Shastri gave a talk on "She is an Astronomer", in addition to talks on Understanding the Sun, and Ancient Indian Astronomy. In the session on Science Communication, Sabyasachi Chatterjee gave a talk on "A Peoples' Science Perspective on Science Communication".

(IYA team)

Sky-watching Workshop for IIA Staff

As part of IIA's preparations to conducting outreach programmes, a sky-watching workshop was conducted at the Bangalore campus on the 4th February, 2009. C. Muthumariappan, S. Pukalenthi, K. Kuppuswamy and K. Jayakumar from VBO were the primary resource persons. A total of about 25 IIA staff as well as teachers from the Madivaala High School with whom IIA has an on-going extension programme, participated. Compilation of night-sky objects likely to be visible at different sky-background levels, sky-watching tips, FAQs during sky-watching programmes, etc. were discussed. There were also demos of Sun-watching, the box spectrograph and night-sky watching.

(IYA team)

IYA09 Workshop at the Karnataka Education Conference of Teachers

About 700 teachers who had gathered from all over Karnataka in the city of Bidar for the 'Shaikshanika Habba' or Education Festival, were exposed to exciting concepts of astronomy that they could take back to their schools to supplement the material in their curricula. The festival, which took place on the 6th and 7th of March, was organised by the Bharatiya Gyan Vigyan Parishat and supported by the governmental 'Sarva Shiksha Abhiyan' programme. At the session devoted to astronomy, Prajval Shastri of IIA gave a lecture that covered Galileo's work, the goals of the International Year of Astronomy, the gender question and the significance of the 'She is an Astronomer' project, and concepts in astronomy that could be taught in the class room and outside that would bring to children in schools the fascination of both exploring the cosmos and using the scientific method. The extensive discussions that followed made it clear that these teachers were deeply interested in broadening the educational experience of the children, and that astronomy could form an accessible yet exciting route towards this goal.

(IYA team)

5.4 Outreach Events

Outreach on Founders Day at VBO

Founder's day was celebrated on 11th August 2008, at Kavalur with an outreach programme for college students. Sixty physics students and twelve lecturers from different colleges were invited and lectures were delivered by C. Sivaram on *The Sun* and by C. Muthumariappan on *Multiwavelength Astronomy*. A visit to the observing facilities was also organized.

(C. Muthumariappan)

Friday Programme at VBO

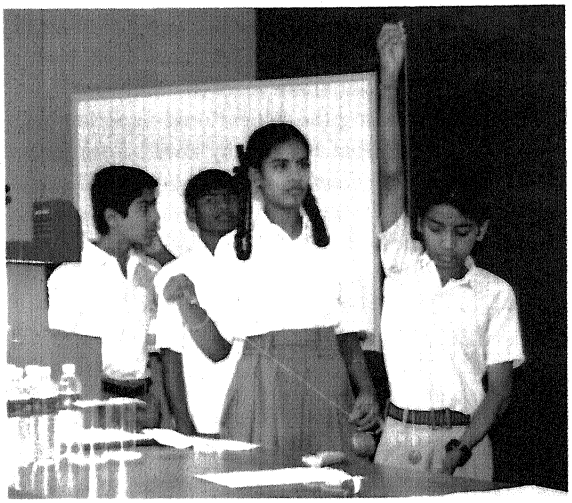
The Vainu Bappu Observatory has a vibrant visitors programme. On the occasion of IYA 2009, a special weekly visitors programme was launched by VBO in November 2008. The programme, arranged upon request, is intended for school/college/university students, and consists of an astronomy lecture, a tour of the observing facilities, an astronomy movie and night-sky watching.

(C. Muthumariappan)

Childrens' Day

As part of IIA's extension programme with the Government High School, Madivaala, a half-day programme for the students was organised on Childrens' Day, 14 November, 2008. There were talks by P. Vishwanath on Galileo and his work, and by Prajval Shastri on the Hubble Deep Field, both in Kannada. A group of children made a presentation on the experiments they had been doing in their school on the simple pendulum. The programme included a demo and sun-watching on the IIA lawns, as well as a movie.

(IYA team)



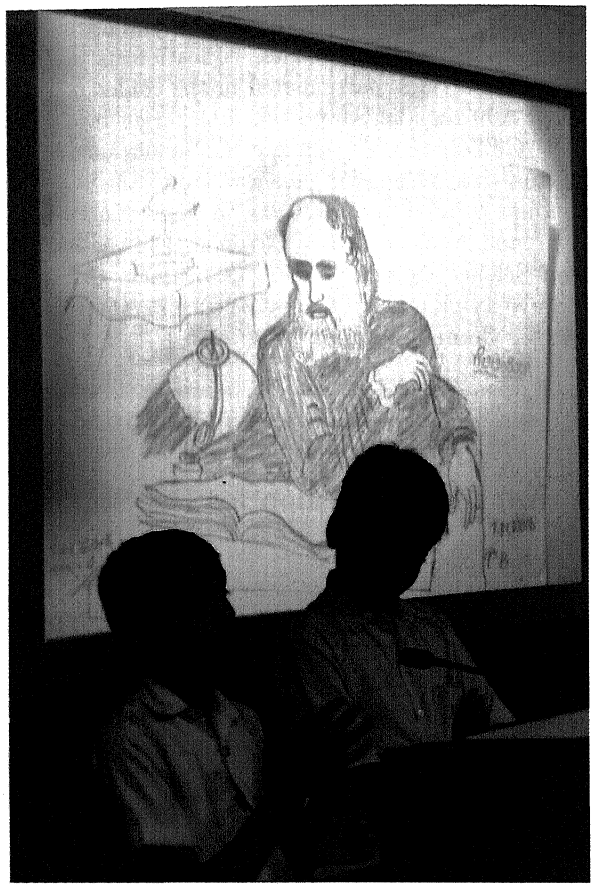
Students from Government High School, Madivaala, demonstrating the experiments they had done at school, Childrens' Day, IIA

Science Day at the Bangalore campus

Science Day at IIA, Bangalore, began with an Astronomy Painting Competition for the children of Madivaala High School, with whom IIA has been running an extension programme for just over a year. About eighty children turned out delightful paintings that depicted the sky, telescopes, rockets and Galileo.

A total of 250 students in two batches listened to talks on galaxies, synthesis of the elements, the Sun, and ancient astronomy. There was also a sun viewing session. A special feature was presentations on astronomy by these students. The children from Government High School, Madivaala, made remarkable presentations in Kannada on star formation, constellations and an overview of astrophysics.

Sun-viewing at IIA on Childrens' Day



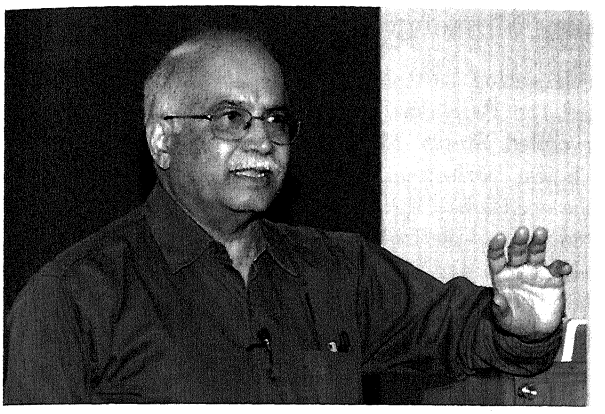
Children from Government High School, Madivaala making a presentation on topics in astrophysics on Science Day

There was a sky-watching session after dusk for students, IIA staff, families and friends. The session was lead by S. Pukalenthi. The 6 inch and 14 inch telescopes were used, with Venus, moon and saturn being prime targets, in addition to several double stars.

(IYA team)

Science Day at VBO

Science Day at VBO had about 700 students and public visiting, including students and teachers from the Rajiv Gandhi College of Engineering (Chennai), MI Teachers Training institute (Tiruppattur), PUE school (Jordanpatti) and Social Welfare Home (Selam). The visitors had a tour of the observatory facilities conducted by C Velu and N Dinakaran. About 500 of the visitors stayed for the night-sky watching programme lead by K Kuppuswamy.



R. Rajaraman, particle physicist from Jawaharlal Nehru University, delivering the first Landmarks in Astronomy lecture on the life and work of Hans Bethe.

Lecture Series on Landmarks in Astronomy

On the occasion of the International Year of Astronomy, IIA launched a special series of public lectures to highlight landmark discoveries in astrophysics. The lectures are intended to describe the work of eminent scientists who have not only made oustanding contributions to the advancement of astrophysics but also have had a special impact on human society.

The Landmark Public Lecture series was inaugurated by a lecture on Hans Bethe by R. Rajaraman of the Jawaharlal Nehru University, New Delhi, on the 13th March, 2009. He spoke on 'Hans Albrecht Bethe: A Giant in Physics and a Statesman in Nuclear Disarmament'. A student of Hans Bethe, the speaker recalled the extraordinary sweep that Hans Bethes scientific contributions had, encompassing several areas of quantum physics, nuclear physics and statistical mechanics. It was for his work on the energy production in stars that Hans Bethe was awarded the Nobel Prize in Physics in 1967.

The lecture was attended by a large audience comprising the scientific community, students, teachers and members of the public. The speaker was introduced by the Siraj Hasan, Director, IIA, who recalled the days when he was a student of Professor Rajaraman at the Delhi University. He also explained the aims of the Landmark series of lectures, in terms of the perspectives of the IYA 2009.

(IYA team)

Pride of India

School students with R.C. Kapoor at the IIA stall.

As part of the IYA 2009 celebrations, IIA participated in the exhibition conducted by the DST during the 96th Indian Science Congress, Shillong January 3 – 7, 2009. R. C. Kapoor and T. K. Murali Das organized an astronomy exhibition stall, at the beautiful campus of the North Eastern Hill University (NEHU), Shillong in Meghalaya.

The IIA stall was visited by a large number of people from all walks of life. This included the Members of Parliament, the Vice Chancellor of the NEHU, scientists, school and college students and the general public alike. The exhibits related to the facilities of the Institute and the subject of astronomy. The exhibits showcased the Institute's campuses at Kodaikanal, Kavalur, Gauribidanur, Bangalore, Hosakote and Hanle where specialized equipment for frontline research is installed. The exhibits communicate in a simple language the important achievements of the Institute, several interesting astrophysical phenomena and the theme of the IYA 2009 to a common person. There was a continuous play of the Institute's film and an astronomy film, "Cosmic Collisions" which were well appreciated. In total, the exhibition evoked a good response.

(R. C. Kapoor)

5.5 IYA Celebrated at the ASI 2009

Amateur & Professional Astronomers Meet

On the 17th February, 2009, the day before the scientific sessions of the meeting of the ASI began, the ASI and the Bangalore Planetarium co-organized a workshop titled "Amateur Astronomy: Pro-Am Collaboration" at the planetarium. Amateurs and professionals from all over the country took part.

Amateur astronomers who ran the "Messier Marathon" at IIA's Hosakote campus. (Photo credit: Naveen Nanjundappa, Bangalore Astronomical Society).

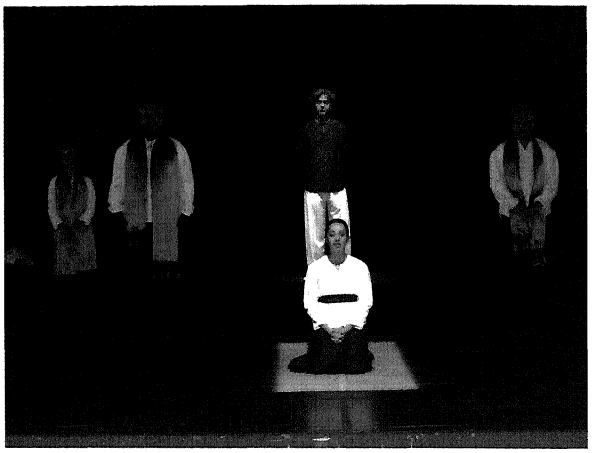
Several IIA scientists participated, and Vasundhara Raju gave an invited talk on 'Asteroid Occultation: Amateur-Professional Collaboration'. The discussions made a clear case for substantive collaborative possibilities between amateurs and professionals. The gathering with so many talented and enthusiastic amateur astronomers inspired by the beauty of the cosmos made for a highly energising experience. The discussion session was followed by a 'Messier Marathon' of sky-watching at IIA's Hosakote campus, co-ordinated by Tushar Prabhu.

Amateur Astronomers' Photo Exhibit

At the venue of the ASI meeting held at IIA, a digital photo exhibit was put together, showcasing astrophotography work by amateur astronomers from all over India. The exhibit was in the form of a running slide-show on a computer monitor in the lobby of the auditorium, and had about 70 beautiful photographs. With the permission of the contributors, this slide-show is also available on IIA's webpage.

Starry Messenger

In celebrating astronomy in IYA09, IIA commissioned the Bangalore Little Theatre to produce a play called Starry Messenger, by Ira Hauptman, which was performed on the 19th February, 2009, on the occasion of the Meeting of the ASI which IIA hosted. It was the first performance of the play outside of the United States, and was in the auditorium of the St. Johns Medical College, near IIA. The play was attended by the delegates of the ASI, as well as IIA staff, families and friends.



A scene from the the play *Starry Messenger*

The play takes a surreal look at the life of Galileo Galilei through the lens of retrospection. Cardinals of the Catholic Church, who, during their lifetimes, hounded and threatened to kill Galileo for his heretic claims, catch up with him in the after life. The cardinals attempt to investigate the sincerity with which Galileo had recanted. They morph into characters that were the largest influences in Galileo's life, namely, his daughters, son and most ardent pupil, and in so doing, attempt to make him relive the many stages that led to the final moment of his recantation. As hard-nosed as the Cardinals were, there were also those among them who were sympathetic towards the great scientist. Those sympathies too follow in the afterlife. It was history being told as a tale.

The playwright Ira Hauptman is a Professor of theater studies at Queens College, City University of New York, USA. The play, which was a part of BLT's History of Ideas project, was directed by Anand Ramprasad, and mentored by Vijay Padaki. It had Deepak Srinivasan, Romal M Singh, Kanchan Bhattacharyya, Shwetha Jairam and Shree Lakshmi J Rao in the caste. The production was managed by

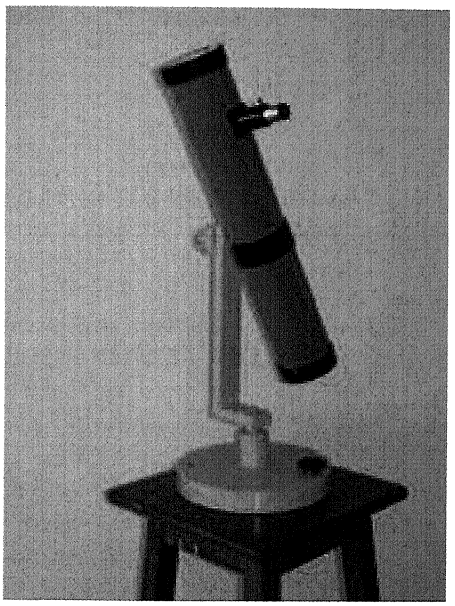
Priyalakshmi Rao and design and execution of lights were by Pritham Kumar.

(IYA team)

5.6 Educational Kits

Newtonian Galileoscope

A 4 inch low cost simple Newtonian telescope has been designed and developed. After the development of the prototype, one thousand telescopes will be manufactured as part of IIA's IYA 2009 programme. The prototype is shown in the photograph.



The prototype of the 4 inch low-cost Newtonian telescope developed by IIA

(Photonics Division)

Solar Radio Interferometer

A two-element interferometer kit, operating at 170 MHz, developed by IIA during the International Heliophysical Year, continues to be used for IIA's outreach activities. One kit was presented to the students of Mohanlal Sukhadia University (MLS), Udaipur on 27 August 2008, for use in their M.Sc. programme. The MLS University was joined by the Rajasthan Technical University also in Udaipur as a partner, to share the equipment for their engineering students to also learn radio astronomy. The students of both the universities were at IIA during 24 - 29 August 2008 and were trained by Dr R.Ramesh and his team at Gauribidanur Observatory on how to install and use the equipment. They learnt the basics of radio interferometry in the process. They also carried out observations of Sun and Cygnus A with the equipment during their stay at Gauribidanur.

The analog and digital receiver boxes of the radio kit. The output of the digital receiver is interfaced to the lap top via an USB cable. Students of Mohanlal Sukhadia University and Rajasthan Technical university can be seen in the background.

Students of St.Xavier's college, Kolkata carrying out RF measurements with the antenna (foreground) they designed at the Gauribidanur observatory along with out institute staff.

The second IHY radio kit was handed over by the Director, Professor Siraj Hasan to the staff and students of St.Xaviers college, Kolkata on 26 February 2009. St.Xaviers college and Bose Institute, Kolkata are jointly conducting a post-graduate programme in Physics with specialization in Astrophysics and Space Science since 2007. They had written to Prof. Hasan requesting to make use of the radio interferometer kit for the observational part of their programme. The students along with their staff members were with us during 22-26 February 2009 and were trained at the Gauribidanur observatory by the members of the radio astronomy group of our institute on how to fabricate, install and use the equipment. They also learnt the basics of radio astronomy in the process.

(Radio Astronomy Group)

Box Spectrograph

The Box Spectrograph, which was developed by IIA during the International Heliophysical Year for distribution, continues to be made and used for distribution as part of IIA's outreach activities. This simple construction can be used to view the spectrum of sunlight, fluorescent light or light from a sodium lamp. Inside the box is a commercially available CD which acts as a reflection grating.

(IHY team)

5.7 The 100-lecture Series

A major outreach activity initiated by IIA in IYA09 is the '100 lectures series', a set of 100 public lectures to be given by IIA scientists to student and public audiences country-wide. This series was kicked off by Tushar Prabhu, with a lecture at Milind Science College, Aurangabad, on the 20th January, 2009, on *Evolution of Telescopes and the Indian Astronomical Observatory.* This was the keynote address at a national-level Seminar on 'Observational Facilities for Astronomical Studies'. The other talks given in this series are listed in this section.

(IYA team)

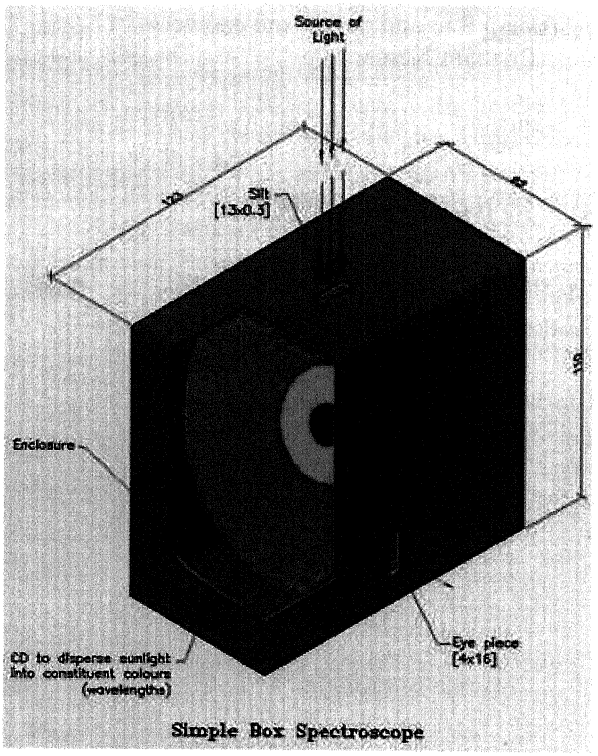


Diagram of the Box Spectrograph, which uses a compact disc as a grating

5.8 Popular Talks & Articles

Talks

L. W. Acton Montana State University, Bozeman, USA gave a talk titled *Space Travel and Space Research*, on 16 February 2009, at IIA.

D. Angchuk gave a talk on *Indian Astronomical Observatory: Astronomy at High Altitudes and its Future*, Defence Institute for High Altitude Research, Leh 28 February, 2009

D. Banerjee gave the following public lectures: Lamdon Model Senior secondary school, Leh, Jammu and Kashmir, *The Sun*, 1 March, 2009; Bangalore Science Forum, *Our nearest star, the Sun* Bose Institute, Kolkata, *The Sun and the solar eclipses*, 5 April, 2008; Al Ameen School, Midnapoore, West Bengal, *A Journey towards our nearest star, the sun*, 17 April, 2008

R. K. Banyal gave a talk on *Ancient Astronomy* on IIA Science Day, 28 February, 2009

B. C. Bhatt gave a talk on *Astronomy: An Observational Science, Vivekananda High School,* Sulebele, Hosakote Taluk, Karnataka, 31 January, 2009; On 26 August 2008 he gave a talk titled *Birth of Stars* to children visiting IIA under the aegis of the Oracle Foundation

S. Chatterjee gave the following talks: *How Thick is our Galaxy?*, Physics department, Tezpur University, 18 April, 2008, in the Physics Department, Mohan Lal Sukhadia University, Udaipur on 23 October, 2008, and in the Physics Department, Rajasthan Univeristy, Jaipur on 13 December, 2008; *Revolutionaries in Science: Galileo and Darwin*, Vijnan Darshan, Bangalore, 12 February, 2009; *A Journey into our Galaxy*, Mariam Nivas School, Bangalore, 14 February, 2009; *Revolutionaries in Science: Galileo and Darwin*, Association for India's Development, Bangalore, 22 February, 2009; *A Journey into our Galaxy*, Kendriya Vidyalaya, IISc, Bangalore , 27 February, 2009; *How Thick is our Galaxy ?*, NMKRV College, Bangalore, 28 February, 2009

E. Ebenezer gave a talk on *Sun with STEREO*, IIA Science Day, 28 February, 2009

A. Goswami gave a talk on *A cosmic journey: from hydrogen to iron and beyond* IIA, Bangalore, IIA Science Day, February 28, 2009

D. Gough University of Cambridge, UK, gave the *2nd Vainu Bappu Memorial Lecture: What is a Sunspot ?* on 03 December 2008

S. S. Hasan gave the following popular talks: *Insights in to the mysteries of the Sun*, National Science Day celebrations, IISc, Bangalore, February 27, 2009; *New developments in understanding our nearest star: The Sun*, National Science Day, IIT Delhi, February 28, 2009; *Understanding the secrets of the Sun*, National Science celebrations, Indian Institute of Chemical Technology, Hyderabad, March 9, 2009

J. Murthy gave the following public talks: 26 August 2008 : *Search for Extra-Terrestrial Intelligence* at IIA, Bangalore; October 4 – 5, 2008, Talks on *SETI and Space Astronomy* at BITS, Pilani, December 1, 2008, Baselius College, Kottayam: *ISM*; December 2, 2008, St. Thomas College, Pala: *Space Astronomy*; December 2, 2008, Newman College, Thodupuzha: *ISM*; January 23, 2009, Open day at St. Francis School: Guest of Honour; February 21, 2009, *Space Astronomy* at St. Josephs; February 28, 2009, *ISM* at St. Josephs; March 2 – 3, 2009, 3 lectures at Karnatak University, Dharwad; March 3, 2009, Talk on *Space Astronomy* at Karnatak Science College, Dharwad; April 20, 2009, *Space Astronomy* at MP Birla Institute of Fundamental Research, Bangalore; 26 August 2008, *Search for Extra-Terrestrial Intelligence at IIA.*

C. Muthumariappan gave the following talks : to college students, during the Founder's day celebration at VBO on 11 August 2008, on *Multiwavelength Astronomy*; to the students of Lady Doak college, Madurai, at VBO on 19 November 2008, on *Multiwavelength Astronomy*; and to college students for the National Science Day celebration at VBO on *Astronomical Instrumentation*

K. Nagaraju gave a talk on *Astronomy Observing Techniques*, at Siddaganga College, Tumkur, Karnataka, 16 February, 2009

P. Parihar gave following talks at the Milind Science College, Aurangabad : *Observing Variable Stars Using Small Telescope*, January 20, 2009 and *Orion Nebula: A Stellar Nursery*, January 21, 2009.

T. P. Prabhu gave the following talks : on *Through the galileoscope: Lighting up the darkness* at one-day seminar as a part of IYA, IIA, Bangalore, 4 April 2008; on *Galaxies* at BASE summer programme, Nehru Planetarium Bangalore, on 16 May 2008; on *Universe* at Government Higher Secondary School, Madivaala, Bangalore, in Kannada in July 2008; on *Our Cosmic Environment* at Amateur Astronomers Meet, Nehru Planetarium, Bangalore, 12 July 2008; a popular talk on *Supernovae* at Nehru Planetarium, New Delhi, on 7 September 2008; *Effects of Atmosphere on Astronomical Observations*, Madhava Observatory, University of Calicut, 19 March, 2009; on *Astronomy from High Altitudes* at Government Degree College, Leh 30 March 2009, Lamdon Higher Secondary School and Moravian Mission Higher Secondary School, Leh 31 March, 2009; on *Our Cosmic Environment*, Lamdon Higher Secondary School, Leh, 31 March, 2009; *Our Cosmic Environment*, Moravian Mission High School, Leh, 31 March.

T. P. Prabhu was interviewed by NDTV for a programme which was preparatory to Chandrayaan launch and aired on 15 October, 2008.

S. Pukalenthi gave a talk on *History of Astronomy* -in Tamil, on VBO Science Day.

R. Rajaraman gave a popular talk Jawaharlal Nehru University, New Delhi on *Hans Albrecht Bethe: A Giant in Physics and a Statesman in Nuclear Disarmament* on 13 March 2009

K. B. Ramesh gave two guest lectures *Chandrayaan-1 – A Journey to the Moon* and *The Sun-Earth Relationship* on 27 February, 2009, at the Christ Academy School, Bangalore; *Living with active star*, Jayaraj Annapakiam College for Women, Periyakulam, Theni district, Tamilnadu, 23 March, 2009

S. Ramya gave a talk on *The Mystery of Galaxies* on IIA Science Day, 28 February, 2009.

N. Shantikumar Singh gave two talks titled *An Introduction to Astronomy & Astrophysics* to the students of the Cambridge Hr. Sec. School, Khergao, Imphal, Manipur on June 4, 2009 and *Science with the Himalayan Chandra Telescope*, Department of Physics, Manipur University, Canchipur, Imphal, Manipur, June 6, 2009.

P. Shastri gave the following talks : *Galaxies and their Blackholes*, Bangalore Planetarium, 9th May, 2008; *The Hubble Ultradeep Field*, in Kannada, Childrens' Day IYA programme at IIA, 14 November 2008; *She is an Astronomer and the International Year of Astronomy* 21 December 2008, All India Peoples Science Congress, Ranchi; *Aakaashagange* (in Kannada), Madivaala High School, Bangalore, 16 February, 2009; *The International Year of Astronomy* in Kannada, Karnataka Education Festival & Teachers' Conference, Bidar, Karnataka, 7th March, 2009.

C. Sivaram, on the occasion of the launch of Chandrayaan, participated in live telecast on CNN IBN channel as expert commentator, October 22, 2008. He is the Editor of the *Astrobiology* Newsletter and has successfully brought out issues of the same. In connection with IYA he has given several lecture outside IIA. C Sivaram also gave a talk on *Astrobiology*, St Joseph's College, 28 February, 2009. On 18 June 2008, C. Sivaram gave a talk on *Dark Universe* at IIA, Bangalore.

K. R. Subramanian gave a talk on *Low frequency solar radio astronomy*, to students of University of Vale do Paraba San Jose Dos Compos, Brazil on August 3, 2008 ; He gave a talk on *Radio sky* to students of Vijaya college, Bangalore under the programme conducted by Karnataka Vigyana Parishat on September 11, 2008; He gave two lectures on *Radio Astronomy* to students of certificate course on *Rocket and space dynamics* conducted by St.Joseph's College, Bangalore in collaboration with ISRO on January 13, 2009 and January 26, 2009. He gave several lectures on basic *Radio Astronomy* to students of certificate course in astronomy conducted by the BIFR, Bangalore during May, October 2008.

S. Sundara Raman presented the key note address and delivered lectures on *Basics of Astrophysics and Solar Physics* on April 11 2008 at IRTT, Erode; he delivered the Professor P. Devadas Endowment Lecture of the Tamil Nadu Government on *Astrophysics and Solar Physics* June 9, 2008, Anna Science Centre, Chennai; He presented a lecture titled *Sun – Our Star* in the state level intercollegiate meet, PHYSKNIT – 2K8, Fatima College, Madurai, on October 15, 2008; He delivered the key note address on *Importance of Basic Science* followed by a lecture on *Astrophysics & Solar Physics* at the Science Association of K. S. Rangasamy College of Technology, Erode on November 21, 2008. He delivered two lectures on March 9, 2009 at Jamal Mohammed College, Trichy on topics *Exploring the Universe and Sun as a Star*; He interacted with the postgraduate Physics students of all the colleges at Trichy in the Anna Science Centre March 9, 2009 in the programme 'Meet Your Scientist' and delivered lectures on *Scope in Solar Physics and Studies & Facilities at Kodaikanal Observatory*; He conducted an in-service training programme for the Tamil Nadu College Teachers (Science Faculty) on *Space Learning* on December 26 – 27, 2008 in the UGC - Academy staff college, Bharathidasan University, Trichy. He also gave a talk on *Solar physics at Kodaikanal Observatory*, Rev. Jacob Memorial Christian College, Ambilikkai, Dindigul Dist. (28 February, 2009)

P. R. Vishwanath gave the following talks : *Galileo, the Scientist and the Man,* IIA, Bangalore, November 2008 and TIFR, January 2009; TIFR, Mumbai, January 2009; Jawaharlal Nehru Planetarium, Delhi, 4 February 2009; Physics Department, University of Guwahati, Guwahati, March 2009. *Galileo and Sky* in Kannada at IIA, Bangalore, November 2008; *Akaasha Mattu Galileo* (in Kannada) Bharatiya Gya na Vigyana Sangha, Hassan, 15 February 2009. He also gave the talk titled *Some Aspects of Science Writing*, IIA, April 2008; *Galileo, the scientist and the man*, Physics Department, University of Guwahati, 26 March, 2009.

Articles

Chatterjee, S., 2008, Equitable Education
The International Year of Astronomy

Chatterjee, S., 2009, Hosathu
Khagola Vijnanada Antara Rashtriya Varsha, The International Year of Astronomy, (in Kannada)

Kapoor, R. C., 2008, The Hawk (Haridwar), December 2, 2008
In the Pursuit of Stars and Some Sunshine - IIA Commemorates the Discovery of Evershed Effect

Kapoor, R. C., 2008, The Hawk, May 10, 2008
Mars Past Day

Kapoor, R. C., 2008, The Hawk, June 11, 2008
In the Quest for Life Elsewhere - Is it on the Planet Mars

Kapoor, R. C., 2008, The Hawk, July 11, 2008
Mars and Saturn Conjunction

Kapoor, R. C., 2008, The Hawk, Nov 14, 2008
Chandrayaan - 1: A trip to Moon

Shastri, P., 2009, *Meandering into Astrophysics,* in Lilavati's Daughters: The Women Scientists of India, Indian Academy of Sciences.

Sivaram, C., 2009, Physics Education.
Black Holes and the LHC

Sivaram, C., 2008, Deccan Herald, Science and Technology, July 2, 2008
Tunguska: 100 years after

Sivaram, C., 2008, Deccan Herald, Science and Technology, October 14, 2008
Extrasolar Planets:Light Years Away

Sivaram, C., 2008, Deccan Herald, Science and Technology, December 9, 2008
Are we Talking Moonshine ?

Sivaram, C., 2008, Deccan Herald, Science and Technology, December 23, 2008
The Magic of 0.177!

Sivaram, C., Deccan Herald, Science and Technology, January 6, 2009
What the Stars Tell

Sivaram, C., Deccan Herald, Science and Technology, January 27, 2009
Cosmic Connection

Sivaram, C., Deccan Herald, Science and Technology, March 24, 2009
Dark Matter of our Vast Universe (through LHC collider)

Vishwanath, P. R., 2008, a weekly column on "History of Modern Physics" in Kannada Prabha, April 2008 - March 2009
Jnana - Vijnana

Chapter 6

Miscellaneous Activities by IIA Staff

6.1 Invited & Contributed Talks

S. P. Bagare gave an invited talk titled *A Revisit to the Phenomenon of Classic Wilson Effect in Sunspots* at the international conference on "Magnetic coupling between the interior and the atmosphere of the Sun", at IIA, Bangalore, during December 2 – 5, 2008. He also gave an invited talk titled *Spectroscopic Techniques used in Optical Solar Observations* at the International Conference on "Recent Advances in Spectroscopy," held at Kodaikanal, during January 28 – 31, 2009.

D. Banerjee gave the following invited talks : "Indo-China workshop" at Kunming, China, *Coronal Holes and the Fast Solar Wind*, 7 August, 2008; PRL, Ahmedabad *Waves in the Solar Corona* on 4, March, 2009; Udaipur Solar Observatory, *Waves in the Coronal Holes as seen from SoHO and Hinode*, 3 March, 2009; Thaltej campus of PRL, *Propagating Disturbances in the Corona and Coronal Seismology*, 5 March, 2009; "Spectroscopy workshop" at Kodaikanal, *Dynamics of Transition Region as seen by UV Spectrometers*, 28 – 31 February, 2009; Invited lecture "On Solar Eclipse workshop" at Delhi University, organised by SPACE, *Corona as seen from Space*, 9 January, 2009; International lecture in "Evershed conference", IIA, Bangalore, *Waves in the coronal holes*, 4 December, 2008.

R. K. Chaudhuri delivered a talk titled *Reappraisal of Cis Effect in 1,2-dihaloethenes: An Improved Virtual Orbital (VO) Multi-reference Approach* at the conference on "Quantum Chemistry, Soft Computing and Optimization" at the Indian Association for the Cultivation of Science, Kolkata, 4 April - 5 April, 2008. Chaudhuri also delivered an invited talk titled *Improved Virtual Orbital Based Multi-Reference Perturbation Theory and its Applications* at the International conference on "Atomic and Nuclear Developments in Coupled Cluster Methods" held (28 June – 5 July, 2008) at the Institute of Nuclear Theory (INT), University of Washington, Seattle.

B. P. Das gave invited talks at "International Conference on the Origins of P, CP and T Violations", Abdus Salam International Centre for Theoretical Physics, Trieste, Italy, July, 2008, *Theory of P and T Violations: Present Status and Future Prospects*; "International Workshop on Atomic, Chemical and Nuclear Developments in Coupled Cluster Methods", National Institute for Nuclear Theory, Seattle, USA, July 2008, *Applications of the Relativistic Coupled Cluster Theory to Strong Correlations in Heavy Atomic Systems*; "International Conference on Cold Atoms", IISER, Kolkata, December 2008, *Quantum Phase Transitions in Cold Bosonic Atoms*; "BRNS-DAE Symposium on Atomic, Molecular and Optical Physics", New Delhi, February 2009, *High Performance Computing Aspects of Cold Atoms in Optical Lattices*

R. T. Gangadhara attended the workshop on "Low-Frequency Pulsar Science" held during June 23 – 27, 2008 at Leiden University, The Netherlands, and gave an invited oral presentation on *Polarization of Radiation Emitted by Relativistic Sources in Pulsars. Gangadhara* also participated in the workshop on "Low-Frequency Radio Universe" held during December 8 – 12, 2008 at NCRA, Pune, and gave an invited oral presentation on the *Modeling of Polarization of Radio Pulsars.*

S. Giridhar gave two invited talks at the Kodai School on *Nucleosynthesis in Stars*and *Spectral Classification I & II* on May 8, 2008.

S. S. Hasan gave an Invited review on *Dynamics and Heating of the Magnetized Chromosphere*, Fourth "Asia Oceania Geosciences Society Meeting", Busan,

Korea, June 16 – 20, 2008; Led a 10 member Indian delegation to participate in the "2nd Indo-China workshop on Solar Physics" in Kunming, China, August 7 – 8, 2008 and gave an invited review on *New insights on dynamics of the magnetic network on the Sun*; "12th European Solar Physics meeting", Freiburg, Germany, Sept. 7 – 12, 2008; invited review on *Processes in the magnetized chromosphere of the Sun*, September 15-19, 2008: "International Astronomical Union Symposium 257", Ionnina, Greece; Chair of the SOC of the Conference "Magnetic Coupling between the Interior and the Atmosphere of the Sun" to commemorate the Discovery of the Evershed Effect, December 2-5, 2008, Bangalore. Gave the opening talk on *Physics at the Kodaikanal Observatory: A historical perspective* in the inaugural session of this meeting; Opening Ceremony of the "International Year of Astronomy", January 15 – 16, 2009 at UNESCO, Paris, France; *Science with the National Large Solar Telescope*, "27th ASI meeting", Bangalore, February 18 – 20, 2009.

K. M. Hiremath gave invited talks: *Physics of the Solar Cycle : New Views* and *Solar Forcing on the Changing Climate,* at the "Fourth UN/ESA/ NASA/JAXA/BAS Workshop on the International Heliophysical Year 2007 and Basic Space Science", Bulgaria, 2 – 6 June, 2008.

S. V. Mallik attended the International Conference on "Recent Advances in Spectroscopy" at Kodaikanal during January 28 – 31, 2008 and gave a talk on *Simultaneous X-ray and Optical Observations of the T Tauri star TW Hya.*

A. Mangalam gave the following invited lectures : *Basic Properties of Nuclei* at the "School on Synthesis of Elements in Stars", 29 April – 13 May, 2008 at the Kodaikanal Observatory; *Vorticity and other interesting issues in Astrophysics* at a workshop on "Emerging fields in mathematics" on 7 March, 2009, held at the Department of Mathematics, MES college, Bangalore.

S. Mathur gave a talk at the GONG 2008/SOHO21 from August 10 – 15, 2008 titled *What can we learn on the structure and the dynamics of the solar core with g modes ?* She gave an invited talk titled *The Quest of Solar Gravity Modes : Probing the solar interior* at the 27th ASI Meeting, held February 18 – 20, 2009, Bangalore.

J. Murthy gave talks on *Advances in Observational Astronomy*, December, 2008 (MG University) 2 lectures.

K. N. Nagendra gave an invited talk, *Recent Developments in Polarized Line Formation in Magnetic Fields* at the international conference on "Recent Advances in Spectroscopy: Astrophysical, Theoretical and Experimental Perspective", Kodaikanal Observatory, 28 – 31 January, 2009.

G. Pandey gave the following invited talks : *Neon abundances in hydrogen deficient stars* at the "International Conference on Recent Advances in Spectroscopy", January 28 – 31, 2009 at Kodaikanal; *Fluorine and Stellar Evolution* at the "27th Meeting of the Astronomical Society of India", February 18 – 20, 2009 at IIA, Bangalore.

P. Parihar gave a talk titled *An Improved Technique to Explore Disk Accretion Process in PMS Stars*, at the "International Conference on Recent Advances in Spectroscopy: Theoretical, Astrophysical, and Experimental Perspectives", January 28 – 31, 2009, Kodaikanal.

A. K. Pati gave an invited talk *Star Formation in Galaxies: the Ultraviolet perspective* at the ASI meeting held at IIA, Bangalore Feb 18 – 20, 2009.

T. P. Prabhu gave the following talks: *Keynote Address* entitled *Our Cosmic Environment* at the inaugural session of the "Workshop on Astrophotography and Image Processing", Nehru Planetarium, New Delhi, 3 October 2008; on *Indian Astronomical Observatory, Hanle* at the "Workshop on Astroparticle Physics", TIFR, Ootacamund, 19 December 2008; inaugurated the UGC sponsored "Workshop on Observational Facilities for Astronomical Studies", Milind Science College, Aurangabad, 20 January 2009 and gave the *Keynote Address* on *Indian Astronomical Observatory, Hanle: Facilities and Science*; an invited talk on *Emission Line Diagnostics in Astronomy* at the "International Conference on Recent Advances in Spectroscopy: Astrophysical, Theoretical and Laboratory Perspectives", Kodaikanal Observatory, 30 January 2009; on *Effect of Earth's Atmosphere on Ground-based Astronomical Data* at the "Workshop on Astronomy and Astrophysics", Calicut University, 19 March 2009.

B. R. Prasad gave an invited talk on *Photonics with bR – An Overview*, "Photonics India Review", 2008, 16 – 17 October 2008, IISc, Bangalore.

S. P. Rajaguru gave the following invited talks: on *Sunspot seismology: new time-distance helioseismic diagnostics using deep-focus wave-path geometry* at the "2nd India-China workshop on solar physics", organized by the Chinese Academy of Sciences at the Yunnan Astronomical Observatories, Kunming, China during August 6 – 8, 2008; on *Seismology of Sunspots: Old Needs, New Developments and New Needs* at the meeting "Magnetic Coupling between the Interior and the Atmosphere of the Sun" as part of Centenary Commemoration of the discovery of the Evershed effect held at IIA, Bangalore during December 2 – 7, 2008; on *Magnetic fields and local helioseismology* during the "27th ASI Meeting", held at Bangalore, 18 – 22 February.

K. B. Ramesh participated in the meeting on "Magnetic Coupling between the Interior and the Atmosphere of the Sun", "Centenary Commemoration of the discovery of the Evershed Effect" held at IIA, Bangalore during December 2 – 5, 2008 and presented a talk along with V. S. Rohini, titled *A New Look at the Sunspot Numbers in Relation to Coronal Background X-ray Emission.*

N. K. Rao was invited to give a talk at the "Workshop on Nucleosynthesis" held at Kodaikanal, May 2008 titled *Echelle Spectroscopy at VBT - Instrument and Astrophysics.* He also gave a talk at the "International Conference on Advances in Spectroscopy: Theoretical, Astrophysical, and Experimental Perspectives" held at Kodaikanal, January 30, 2009, titled *High Resolution Spectroscopy of Hydrogen Deficient Stars* (co-author with David L. Lambert).

E. Reddy gave the following invited talks: *The Galactic disk in cosmological context*, at the IAU 254, held at Copenhagen, Denmark, from 9 – 14 June, 2008; chaired a session on "Kinematics and Abundances" and a talk on *Decomposition of the Galactic disk: Observational perspectives*, Physics Department, Delhi University, Delhi; on *FIP phenomenon in stars: Solar connection* in the meeting on "Magnetic Coupling between the Interior and the Atmosphere of the Sun – Centenary Commemoration of the discovery of the Evershed Effect" held at IIA, Bangalore during December 2 – 5, 2008; on *Giant Segmented Mirror Telescopes: Status Report & Discussion*, at the "27th ASI Meeting", held February 18 – 20, 2009, Bangalore.

M. Safonova gave the following talks : *TAUVEX Space Observatory Overview*, May 2008, IPM, Tehran, Iran; *Detection of IMBHs in Globular Clusters*, May 2008, Sharif University of Technology, Tehran, Iran; *Indian Institute of Astrophysics and two projects: TAUVEX Space Observatory and Detecting IMBHs in Globular Clusters by Microlensing from Hanle Observatory*, May 2008, Shamakhy Astrophysical Observatory, Baku, Azerbaijan.

S. K. Saha gave the following invited talks : *High Resolution Imaging* at the "Summer School on astronomy and Astrophysics", VBO, Kavalur, during 15 – 22 May, 2008; *Activities at IIA* at the "Summer School on Physics", Kodaikanal Observatory, during 8 – 21 June, 2008; *Sensors for the High Resolution Astronomical Imaging*, at the 2nd National Workshop on "Advanced Optoelectronic Materials and Devices", during 22 – 24 December, 2008; *Optical Instrumentation: IIA activities* at Banaras Hindu University, on 24 December, 2008; *Optical and IR Sensors for Imaging*, at "Variable Energy Cyclotron Centre, Kolkata", on 2nd March, 2009; *Present Trends in Stellar Interferometry*, at the "International Conf. on Trends in Optics and Photonics", 3 March, 2009.

M. Sampoorna also gave a talk on *Probability distribution functions to represent the solar surface magnetic fields*, at the international conference on "Magnetic Coupling between the Interior and the Atmosphere of the Sun, Centenary Commemoration of the discovery of the Evershed Effect", IIA, Bangalore, India, 2 – 5 December, 2008.

P. Shastri gave an invited talk at the "Indo-South Africa Workshop on Astronomy", ARIES, Nainital, 29 October 2008 – 2 November 2008, titled *Multi-wavelength Investigations of Seyfert Galaxies* ; She presented a poster at the International conference on "Low Frequency Radio Universe," NCRA, TIFR, Pune, 8 – 12 December, 2008; and a poster at the "27th ASI meeting," IIA, Bangalore 18–20 February, 2009. Shastri gave an invited talk titled *Opportunities for Gender Equity: Looking Outwards & Inwards*, in the "National meeting on Universalising the Universe", 4th April 2008, IIA, Bangalore.

V. Singh gave a talk on *X-ray Emission from Seyfert Galaxies and the Unification* in "37th Committee on Space Research assembly" meeting, Montreal, Canada, July 13 – 20, 2008.

*C. Sivaram & Kenath Arun**, gave a lecture on *Cosmological Nucleosynthesis*, at the Workshop on "Stellar nucleosynthesis", Kodaikanal Observatory, May 2008.

M. Srinivasa Rao attended the conference on "XV National Conf. of Astronomers of Serbia", Belgrade, from October 2 – 5, 2008, and presented an invited talk on *Discrete Space Theory of Radiative Transfer: Applications.* He also attended the conference on "Recent Advances in Spectroscopy: Theoretical, Astrophysical, and Experimental Perspectives" at the IIA, Kodaikanal Observatory from January 28 – 31, 2009. An invited talk on *Discrete Space Theory of Radiative Transfer: Applications was presented.*

K. R. Subramanian gave two invited talks on the *Brazilian decimetric array correlator system and Decimetric solar radio emission* in the "BDA workshop" held at INPE, San Jose Doc Compos, Brazil. July 25 and 28, 2008.

N. V. Sujatha gave an invited talk titled *Stellar Properties & Stellar Model in UV*, at the "National Seminar", conducted at Carmel College, Mala, Thrissur, Kerala on 24 February, 2009.

A. Subramaniam attended the IAU symposium 256: "Magellanic Clouds: Stars, gas and galaxies", Keele University, August 2009 and presented a contributed talk titled *Line of sight depth estimation of the Large and Small Magellanic Clouds.*

P. R. Vishwanath gave a talk on *Astrophysics' at Higher Energies*, "National Symposia on Mega Physics", Lady Miranda College, New Delhi, February 2009. He also gave a talk on *Very High Energy Gamma Ray Astronomy* at the "National Workshop on Simulations and Data Analysis", Physics Department , University of Guwahati, Guwahati, March 2009.

6.2 Scientific/Technical Lectures

L. S. Anusha presented a seminar on *Preconditioned Bi-Conjugate Gradient method for Spherical radiative transfer* as a part of the "student talk" on May 29, 2009, at IIA.

B. P. Das gave the following lectures : Department of Physics, University of Texas, Austin, USA, July 2008, *Atomic Electric Dipole Moments as Probes of Physics Beyond the Standard Model*; Indian Association for the Cultivation of Science, Kolkata, December 2008, *Quantum Phase Transitions in Mixtures of Ultracold Bosonic Atoms*; National Institute of Science Education and Research, Bhubaneswar, April, 2009; *Novel Phases of Ultracold Matter & Probing Time-Reversal/CP Violation with Atomic Electric Dipole Moments.*

A. Goswami gave the following oral presentations *Galactic Chemical Evolution: An Introduction,* Kodai school on "Synthesis of Elements in Stars" April 29 – May 13, 2008 Kodaikanal Observatory; *IIA: A World-Class Research Platform for Astronomy and Astrophysics,* Dept of Physics, Gauhati University, December 12, 2008; *Elemental Abundances in CEMP stars: r- and s- Process Elements*; International conference on "Recent Advances in Spectroscopy: Theoretical, Astrophysical and Experimental perspectives" January 28 – 31, 2009, Kodaikanal.

G. R. Gupta gave a talk titled *On Statistical Detection of Waves in Polar Coronal Holes* in Young astronomer's meet 2009, held at the IIT, Kharagpur during March 14 – 16, 2009.

K. B. Ramesh gave a talk on *Living with an Active Star* in an UGC sponsored National Seminar on "Recent Trends in Physics" held during 23 and 24 March, 2009 at Jayaraj Annapackiam College for Women, Periyakulam, Tamilnadu.

S. K. Saha gave a talk on *IIA academic programmes* at the Induction ceremony of IIA – CU Integrated M.Tech – Ph.D (Tech.), Calcutta University, Kolkata on 1 September, 2008. He also gave a talk on *IIA students programmes* at the Pondicherry University, on 27 February, 2009.

M. Sampoorna presented a talk on *58th Lindau Meeting of Nobel Laureates: A Report*, at IIA, August 6, 2008. She also presented a thesis colloquium on *The Nature of Solar Surface Magnetism : Theoretical Approaches Based on Spectropolarimetry*, at Indian Institute of Astrophysics, on September 16, 2008.

Veeresh Singh gave a talk on *X-ray Emission from Seyfert Galaxies and the Unification* in "37th Committee on Space Research assembly" meeting, Montreal, Canada, July 13 – 20, 2008.

P. R. Vishwanath gave the following talks on *Very High Energy gamma Ray Astronomy*, Saha Institute,

Kolkatta, September 2008; *Very High Energy Astrophysics*, IIT, Guwahati, March 2009.

6.3 Attendance in Meetings

G. C. Anupama attended the International School and Workshop on "SNe & GRBs at low z & in the Era of Reionization", held at Darjeeling, India, during 23 – 29 May, 2008. She also attended the 27th Meeting of the Astronomical Society of India, held at IIA, Bangalore, during February 18 – 20, 2009.

L. S. Anusha participated in the workshop on "Etudes a haute resolution de l'atmosphere solaire: de la photosphere a la couronne," Nice, France, October 21 – 23, 2008. She attended the Evershed meeting on "Magnetic Coupling between the Interior and the Atmosphere of the Sun", December 2 – 5, 2008 at Bangalore.

S. P. Bagare attended the "National meeting on total solar eclipse" of June 23, 2008, IIA, Bangalore and the "27th Meeting of the Astronomical Society of India", held at IIA, Bangalore, during February 18 – 20, 2009.

D. Banerjee attended the "Hinode Science Meeting" at Boulder, USA 29 September – 3 October, 2008; Evershed Meeting at Bangalore, December, 2008; Indo-China meeting, at Kunming, China, 7 – 9 August; 27th Meeting of the Astronomical Society of India, held at IIA, Bangalore, during February 18 – 20, 2009.

B. C. Bhatt attended the workshop on "Universalising the Universe" at IIA, Bangalore on April 4, 2008 ; workshop on *Resource material for IYA 2009* at IIA, Bangalore on October 3, 2008; 3rd In-House meeting of IIA during April 15-16, 2008; 27th Meeting of Astronomical Society of India at IIA, Bangalore held during February 18 – 20, 2009.

C. Birdie participated in the NIAS - DST workshop organized by NIAS on "Multi-disciplinary approach in Science & Technology" in June – July 20, 2008. She also participated in the 27th ASI Meeting, IIA, February 18 – 20, 2009.

R. K. Chaudhuri attended the conference on "Quantum Chemistry, Soft Computing and Optimization" at the Indian Association for the Cultivation of Science, Kolkata, 4 April – 5 April, 2008. Chaudhuri also attended the International conference on "Atomic and Nuclear Developments in Coupled Cluster Methods" held at the Institute of Nuclear Theory (INT), University of Washington, Seattle, 28 June – 5 July, 2008.

B. P. Das attended the following conferences "International Conference on the Origins of P, CP and T Violations", Abdus Salam International Centre for Theoretical Physics, Trieste, Italy, July, 2008; "International Workshop on Atomic, Chemical and Nuclear Developments in Coupled Cluster Methods", National Institute for Nuclear Theory, Seattle, USA, July 2008; "International Conference on Cold Atoms", IISER, Kolkata, December, 2008; BRNS-DAE Symposium on Atomic, Molecular and Optical Physics, New Delhi, February, 2009.

R. T. Gangadhara attended the workshop on "Low-Frequency Pulsar Science" held during June 23 - 27, 2008 at Leiden University, The Netherlands. He also participated in the workshop on "Low-Frequency Radio Universe" held during December 8 – 12, 2008 at NCRA, Pune. Gangadhara attended the "The 23rd NIAS Course for Senior Executives" during January 19 – 24, 2009 at National Institute of Advanced Studies, Bangalore. R. T. Gangadhara attended the 25th ASI meeting, 2009, at IIA, Bangalore, during February 18 – 20, 2009.

S. Giridhar attended the Kodai School on "Synthesis of elements in stars" April 29 – May 13, 2008, held at Kodaikanal Observatory.

A. Goswami attended the Kodai school on "Synthesis of elements in stars" April 29 – May 13, 2008, held at Kodaikanal Observatory; National meeting on Large Telescope Projects, September 27, 2008, IIA, Bangalore; "A National meeting on High Resolution Spectroscopic facilities for existing and future National telescopes" September 29, 2008, IIA, Bangalore; "International conference on Recent Advances in Spectroscopy: Theoretical, Astrophysical and Experimental Perspectives" January 28 – 31, 2009, Kodaikanal.

G. R. Gupta attended the Evershed meeting on "Magnetic Coupling between the interior and the atmosphere of the Sun" at IIA, Bangalore during December 2 – 5 2008. He also attended the 25th ASI meeting, held at IIA, Bangalore during February 18 – 20, 2009.

S. S. Hasan attended the fourth Asia Oceania Geosciences Society Meeting, Busan, Korea, June 16 – 20, 2008; He led a 10 member Indian delegation to participate in the 2nd Indo-China workshop on Solar Physics in Kunming, China, August 7 – 8, 2008; *Hasan* attended the 12th "European Solar Physics" meeting, Freiburg, Germany, September 7 – 12, 2008; Invited review on *Processes in the magnetized chromosphere of the Sun*, September 15 – 19, 2008: "International Astronomical Union Symposium 257", Ionnina, Greece; Chair of the SOC of the Conference "Magnetic Coupling between the Interior and the Atmosphere of the Sun" to commemorate the Discovery of the Evershed Effect, December 2 – 5, 2008, Bangalore; Opening Ceremony of the "International Year of Astronomy", January 15 – 16, 2009 at UNESCO, Paris, France; He attended the 27th ASI meeting, Bangalore, February 18 – 20, 2009.

K. M. Hiremath attended the conf. on "Magnetic Coupling between the Interior and the Atmosphere of the Sun", held at IIA, Bangalore, December 2 – 5, 2008. *Hiremath* also participated in the "27th Meeting of the Astronomical Society of India (ASI)", Bangalore, February 18 – 20, 2009. *Hiremath* also participated in the "National meeting on 2009 total solar eclipse", IIA, Bangalore, June 23, 2008, and the "Workshop on Grid Computing", IIA, Bangalore, November 5, 2008.

P. U. Kamath attended the"8th Pacific Rim Conference on Stellar Astrophysics (PRCSA 2008)," held during 5 – 9 May, 2008 at Phuket, Thailand.

R. Kariyappa attended the conf. on "Magnetic Coupling between the Interior and the Atmosphere of the Sun – Centenary Commemoration of the Discovery of the Evershed Effect", held at IIA, Bangalore, December 2 – 5, 2008. He also participated in the 27th ASI Meeting, IIA, February 18 – 20, 2009.

S. Mathur attended the AsteroFLAG workshop at ISSI, Bern (Switzerland) from 8 – 11 December, 2008: work on the pipeline for the KASC (Kepler AsteroSeismic Consortium); GOLF-NG workshop at the CEA, Saclay (France) from December 15 – 19, 2008: work on the GOLF-NG instrument and the analysis of the summer campaign 2008; 27th ASI meeting, February 18 – 20, 2009.

S. V. Mallik attended the International Conference on "Recent Advances in Spectroscopy" at Kodaikanal during January 28 – 31. She also attended the 27th ASI meeting, February 18 – 20, 2009 at IIA, Bangalore.

K. N. Nagendra attended the international conference on "Magnetic Coupling between the Interior and the Atmosphere of the Sun, Centenary Commemoration of the discovery of the Evershed Effect," IIA, Bangalore, India, 2 – 5 December, 2008. He also participated in the international conference on "Recent advances in Spectroscopy: Astrophysical, Theoretical and Experimental Perspective", Kodaikanal Observatory, 28 – 31 January 2009.

Neeharika Verma attended the 2nd IIA - PennState Astrostatistics School, Vainu Bappu Observatory, Kavalur, 7 – 16 July, 2008 and the 27th Meeting of the Astronomical Society of India, February 18 – 20, 2009 at IIA, Bangalore.

G. Pandey attended the following conferences "International Conference on Recent Advances in Spectroscopy", January 28 – 31, 2009 at Kodaikanal; and the 27th Meeting of the Astronomical Society of India, February 18 – 20, 2009 at IIA, Bangalore.

P. Parihar attended the "International Conference on Recent Advances in Spectroscopy: Theoretical, Astrophysical", and Experimental Perspectives, Kodaikanal, January 28 – 31, 2009.

T. P. Prabhu attended the workshop and seminars : on Supernovae & Gamma-Ray Bursts at low z & in the Era of Reionization, Darjeeling, 25 – 29 May 2008; attended the one-day seminar as a part of IYA at IIA, Bangalore on 4 April 2008; attended the Workshop on Astrophotography and Image Processing, Nehru Planetarium, New Delhi, 3 – 6 October 2008; attended the workshop on Astroparticle Physics, TIFR, Ootacamund, 19-20 December 2008; attended the UGC sponsored workshop on Observational Facilities for Astronomical Studies, Milind Science College, Aurangabad, 20 – 21 January 2009; attended the International Conference on Recent Advances on Astrophysical, Theoretical and Laboratory Perspectives, Kodaikanal Observatory, 28 – 31 January 2009.

B. R. Prasad attended the 27th Meeting of the Astronomical Society of India, February 18 – 20, 2009 at IIA, Bangalore.

S. P. Rajaguru attended the 2nd India-China work-

shop on solar physics, organized by the Chinese Academy of Sciences at the Yunnan Astronomical Observatories, Kunming, China during August 6 – 8, 2008. He also attended the meeting "Magnetic Coupling between the Interior and the Atmosphere of the Sun" as part of Centenary Commemoration of the discovery of the Evershed effect held at IIA, Bangalore during December 2 – 7, 2008.

K. P. Raju attended the meeting on "Magnetic Coupling between the Interior and the Atmosphere of the Sun – Centenary Commemoration of the discovery of the Evershed Effect" held at IIA, Bangalore during December 2 – 5, 2008. He also participated in the 27th ASI Meeting, IIA, February 18 – 20, 2009.

*K. B. Ramesh & V. S. Rohini** attended the meeting on "Magnetic Coupling between the Interior and the Atmosphere of the Sun – Centenary Commemoration of the discovery of the Evershed Effect" held at IIA, Bangalore during December 2 – 5, 2008.

K. E. Rangarajan attended the AGU-SFO conference from December 14 – 19, 2008; the Summer School on "Experimental Physics" held from June 9 – 21, 2008; "Summer School in Physics", June 9 – 21, 2008; International conference on "Recent advances in Spectroscopy: Astrophysical, Theoretical and Laboratory Perspectives", January 28 – 31, 2009 at Kodaikanal Observatory, India.

N. K. Rao attended the workshop on "NucleoSynthesis" held at Kodaikanal, May 2008 and also the Intl Conference on "Advances in Spectroscopy: Theoretical, Astrophysical, and Experimental Perspectives".

E. Reddy attended the meeting on "Magnetic Coupling between the Interior and the Atmosphere of the Sun – Centenary Commemoration of the discovery of the Evershed Effect" held at IIA, Bangalore during December 2 – 5, 2008.

S. K. Saha chaired a session of the 2nd "National Workshop on Advanced Optoelectronic Materials and Devices", on December 23, 2008, at Banaras Hindu University, Varanasi. He chaired two sessions of the "International Conf. on Trends in Optics and Photonics", on March 2 – 3, 2009, at Kolkata. *Saha* attended the "27th meeting of the Astronomical Society of India", during 18 – 20 February, 2009, Bangalore. He attended the "National meeting on India's participation in Large telescope project", on September 17, 2008, Bangalore.

M. Sampoorna participated in the international conference on "Magnetic Coupling between the Interior and the Atmosphere of the Sun, Centenary Commemoration of the discovery of the Evershed Effect", held at IIA, Bangalore, India, during 2 – 5 December, 2008.

P. Shastri participated in the following conferences: National meeting on Universalising the Universe, 4th April 2008, IIA; Resource Person at the 9th COSPAR Capacity-building Workshop, Kualalampur, June, 2008; Resource Person and organiser, The Second IIA-PennState Astrostatistics School, July, 2008, Vainu Bappu Observatory, Kavalur

M. Srinivasa Rao attended the "XV National Conference of Astronomers of Serbia", Belgrade, from October 2 – 5, 2008. He also attended the conference on "Recent Advances in Spectroscopy: Theoretical, Astrophysical, and Experimental Perspectives" at IIA, Kodaikanal Observatory from January 28 – 31, 2009.

K. R. Subramanian attended the Brazilian Decimetric Array workshop, July 25 – 28, 2008, at INPE, San Jose Dos Compos, Brazil; Evershed meeting on the Magnetic Coupling between the Interior and the Atmosphere of the Sun, December 2 – 5, 2008 at IIA, Bangalore; the 27th ASI meeting, February 18 – 20, 2009 at IIA, Bangalore.

A. Subramaniam attended the IAU symposium 256: "Magellanic Clouds: Stars, gas and galaxies", Keele University, August 2009.

N. V. Sujatha attended the "27th meeting of the Astronomical Society of India", during 18 – 20 February, 2009, Bangalore.

Veeresh Singh participated in "37th Committee on Space Research assembly", held at Montreal, Canada during 13 – 20 July, 2008. He also participated in a conference on "Low Frequency Radio Universe," NCRA, Pune, 8 – 12 December, 2008. He also took part in the "27th ASI meeting," IIA, Bangalore during 18 – 20 February, 2009.

P. R. Vishwanath participated in the "National Symposium on Mega Physics," Lady Miranda College, New Delhi, February, 2009; "National Symposium on Simulations and Data Analysis," Guwahati University, Guwahati, March 2009.

6.4 Collaborations across Institutions

D. Banerjee received a three-year joint research grant for collaborative research between Armagh Observatory, U.K. and Indian Institute of Astrophysics (Bilateral programme between Royal Society London and the British Council India). Dipankar Banerjee is the P.I. from India and J.G. Doyle is the P.I. from U.K. He is the Indian Principal Investigator of a project under DST- DAAD (Indo-German bilateral programme).

K. N. Nagendra, M. Sampoorna & L. S. Anusha are collaborating with *H. Frisch,* Observatoire de la Cote d'Azur, France, on the Topic: "Turbulence theory for Solar Applications"; with *J. O. Stenflo,* ETH Zentrum, Zurich, Switzerland. on the Topic: "Hanle-Zeeman Scattering Theory"; with *M. Bianda,* IRSOL, Locarno, Switzerland, on the Topic: "Observations of the Second Solar Spectrum with ZIMPOL II"; with *R. Ramelli* IRSOL, Locarno, Switzerland, on the Topic: "Observations of the Second Solar Spectrum with ZIMPOL II'.

K. N. Nagendra and *L. S. Anusha* are also collaborating with *Frederic Paletou,* University of Toulouse, France, on the Topic: "Advanced Numerical Methods in Radiative Transfer."

J. Javaraiah has collaborations with UCLA scientists *R. K. Ulrich, L. Bertello and J. E. Boyden* for the work on " Search for short-term periodicities in the Sun's surface rotation", and to study the variations in the solar rotation using Mt. Wilson CaK spectroheliograms measured during the period 1915 – 1985.

S. Mathur has collaborations with CEA, Saclay (France): Rafael García and S. Turck-Chize; Insituto de Astrofisica de Canaries, Tenerife (Spain): A. Eff-Darwich, C. Rgulo, D. Salabert, O. L. Creevey; Laboratoire d'Astrophysique de Toulouse-Tarbes, Toulouse (France): J. Ballot; Udaipur Solar Observatory, Udaipur (India): plan to work with B. Kumar.

J. Murthy has collaborations with Ranjan Gupta, H. P. Singh, Archana Bora: *Automated Classification of TAUVEX sources*; Noah Brosch, Hagai Netzer: *TAUVEX*; R. C. Henry, Luciana Bianchi: *GALEX observations*; Boris Shustov, Mikhail Sachkov, Norbert Kappelmann: *WSO planning.*

N. Verma is working with the group at the University of Torino, Italy on the *Measurement of Cosmogenic radionuclides in meteorites using a high purity germanium detector.*

6.5 Externally Funded Projects

Agency : D.S.T.; Dates: October 7, 2009 – 2012
Indo-Mexico project : *Variability in the atmospheres of the sun and stars.*
P. I. from India : Sunetra Giridhar
Co-Investigator from India : Prasad Subramanian
P. I. from Mexico : A. Arellano ferro
Co-Investigator : Alejandro Lara

Agency : DST/SERC
Title of the project : *Development of applications of intruder free multi-reference perturbative and non-perturbative formalisms*
P. I. : R. K. Chaudhuri
Co-Investigator : S. Chattopadhyay and U. S. Mahapatra

Agency : D.S.T/EPFL (Swiss Govt.); Year : 2009 (one month duration)
Indo-Swiss Joint Research Project : *Monitoring of gravitationally lensed quasars*
P. I. from India : C. S. Stalin

Agency : DST ;Year : October 2007 to September 2010
Research Project : *Observations of dust scattering using GALEX*
P. I. : N. V. Sujatha

Agency: ISRO; Year 2004 – 2009
Research Project : *Modeling of the Diffuse UV Sky*
P. I. : J. Murthy

Agency : ISRO ; 2005 – 2009.
Research Project : *TAUVEX Planning and Analysis*
P. I. : J. Murthy

Agency : DST; 2007 – 2009
Research Project : ILTP: *WSO planning*
P. I. : J. Murthy

Agency : DST, New Delhi
Year : 2008 – 2011
Research Project : *Determination and modelling of chemical compositions of metal-poor stars and observational constraints for Galactic chemical evolution*
P. I. : A. Goswami

Agency : DST, New Delhi
Year : October 2007 – September 2010
Research Project: *Observations of Dust scattering Using GALEX*
P. I. : N. V. Sujatha

6.6 Visits by IIA Scientists

L. S. Anusha visited the Observatory of Nice, France for two months October – November 2008, to work on "Stochastic polarized radiative transfer" in collaboration with K. N. Nagendra and Helene Frisch.

D. Banerjee visited the Armagh Observatory, U. K. for three weeks during September 2008, under the Royal Society–British Council joint project grant.

G. R. Gupta visited the Max Planck Institute of Solar System Research, Lindau, Germany during January 14 – 30, 2009 under the DAAD-DST joint project.

S. S. Hasan visited April – May: Harvard Smithsonian Center for Astrophysics, Cambridge, U.S.A from April – May 2008; May 2008 : Kiepenheuer Institute, Freiburg, Germany; June 2008: Paris Observatory, France; Department of Applied Mathematics, University of Sheffield, U.K.; and Institute of Astronomy, Cambridge, U.K.; August 2008: Shanghai region in connection with the total solar eclipse of July 22, 2009.

R. Kariyappa visited the Harvard-Smithsonian Center for Astrophysics, Cambridge, MA, USA during August 10 – 31, 2008 on collaborative research related to the study of X-ray bright points from Hinode/XRT. This is in collaboration with Drs E. E. DeLuca, A. A. van Ballegooijen, S. Steve Saar, L. Golub.

S. Mathur visited CEA, Saclay from December 11 – 19 December, 2008 to work with Rafael García and S. Turck-Chize on the GOLF-NG data; CEA, Saclay from 30 March – 17 April, 2008 to work with Rafael García on the pipeline for the Kepler mission.

S. P. Rajaguru visited the Stanford university, Stanford, CA, USA during April 1 - 4, 2008 on a collaborative work on developing data access systems at IIA for data from NASA's future solar space mission Solar Dynamics Observatory (SDO).

N. K. Rao has spent about three months October – December, 2008 visiting McDonald Observatory, University of Texas at Austin, USA, working on *Hydrogen Deficient stars and related studies.*

E. Reddy visited the Lund Observatory, Lund, Sweden, as a visiting professor, 2 – 21 June, 2008. He gave a seminar on *Stellar abundance peculiarities and magnetic field connection,* 5 June, 2008; 10 – 19 January, 2009: visited Caltech and Carniege Observatories, Pasadena, USA; 13 January, 2009: visited Mirror Lab, University of Arizona, Tuscon, USA; 16 January, 2009: *Overview of Astronomical Facilities in India,* California Institute of Technology, Pasadena, USA; 19 – 25 January, 2009, visited ESO head quarters, Garching, Germany.

M. Sampoorna visited Lindau, Germany, to participate in the 58th Meeting of Nobel Laureates with students/ young researchers, held during 29 June – 4 July 2008. The meeting was attended by 25 Nobel Laureates in Physics, and more than 500 young researchers from 67 countries. Sampoorna particularly discussed with Professors William Phillips, Roy Glauber, Brian Josephson, David Gross, and George Smoot. After the Lindau visit (from 5th to 12th July 2008), she visited the Technical University of Berlin, Free University of Berlin, the Helmholtz-Zentrum Berlin, University of Hamburg, and University of Bonn, Germany. This also included meetings held with Chiefs of the DST and DFG, before and after the 2 weeks long visit to Lindau in Germany.

P. Shastri visited ARIES, Nainital, 29 October 2008 – 2 November 2008.

M. Srinivasa Rao on the invitation from Prof. Mika Juvela, visited Helsinki University Observatory, Finland, from October 8 – 15, 2008 and presented a talk on *Discrete Space Theory of Radiative Transfer: Applications.* They are collaborating on the calculation of hydrogen line ratios in the Seyfert galaxy NGC 4151. *Srinivasa Rao* was also invited by Prof. Bertrand Plez, GRAAL, from October 15 – 20, 2008 and he gave a talk on *Study of Irradiation Effects*

in Close Binary Components. They are collaborating on K1 emission lines from circumstellar shells of N-type star R Scl. On the invitation from Prof. Juan Jorec, *Srinivasa Rao* visited Institut d' Astrophysique de Paris, CNRS, from October 20 – 22, 2008 and gave a talk on *Study of Irradiation Effects in Close Binary Components.* They discussed some aspects of scientific proposals on light curve solutions on OGLE data to derive the physical parameters (like mass, radii, temperature, inclination angle) of binary system.

Veeresh Singh visited NCRA, Pune during 25 August – 2 September, 2008 to work on radio data obtained from GMRT.

P. R. Vishwanath visited Saha Institute, Kolkata, September 2008; TIFR, Mumbai, December – January 2009; J N Planetarium, Delhi February 2009.

6.7 Visitors hosted

A. Arellano Ferro who is collaborating with *S. Giridhar* visited IIA, during December 25, 2008 – January 26, 2009. During this period they have carried out CCD photometry of Globular clusters using the 2 m HCT, during January 7 – 8, 2009. The analysis of the CCD data and the light curve parameterization of variables in the cluster NGC 5053, has been done.

Banerjee hosted the following visits : David Perez-Suarez (Armagh Observatory, U. K.), May 16 – June 2, 2008; Luca Teriaca (Max Planck Institute for Solar System Research, Germany), June 13 – 20, 2008 and 2 – 13 February, 2009; Eamon Schullion (Armagh Observatory, U. K.), 22 November - 6 December 2008; Srividya Subramanian (Armagh Observatory, U. K.), 31 December 2008 – 2 January, 2009

K. N. Nagendra hosted J. O. Stenflo, for collaborative research, 29 November – 25 December, 2008. He was invited by IIA as the first "Vainu Bappu Visiting Professor."

S. P. Rajaguru hosted Dr. Hamed Moradi from the Monash University, Melbourne, Australia from November 16 to December 7, 2008 for collaborative work on 'sunspot seismology'.

S. P. Rajaguru and S.S. Hasan hosted Dr. Shravan Hanasoge from the Stanford University, Stanford, CA from October 1 - December 15, 2008 for collaborative work on sunspot seismology and problems on magnetic field and acoustic wave interactions.

P. Shastri hosted the following visitors Paola di Matteo, Victor Debbatista, Alain Omont.

6.8 Involvement with the scientific community

G. C. Anupama co-organized, with A. K. Ray (TIFR), the international School and Workshop on "SNe & GRBs at low z & in the Era of Reionization", held at Darjeeling, India, during 23 – 29 May, 2008. She organized, as Convenor, LOC, the 27th Meeting of the ASI, held at IIA, Bangalore, during February 18 – 20, 2009. She is also the Editor of the "Bulletin of the Astronomical Society of India" since 2004 March; Member of the review committee for the project " Virtual Observatory India – The Next Generation," (PI: A. K. Kembhavi, IUCAA), funded by the Ministry of Communications and Information Technology; Member of the "Subject Expert Committee on Physical and Mathematical Sciences for technical evaluation of proposals received under Women Scientist Scheme – (WOS-A)".

D. Banerjee was Co-ordinator and member, LOC, of the Evershed Celebrations meeting at IIA.

H. C. Bhatt served as Chair, SOC of the Astronomical Society of India. He also served as member, Programme Advisory Committee on "Plasma, High Energy, Nuclear Physics, Astronomy & Astrophysics and Nonlinear Dynamics" of the DST.

C. Birdie has been invited to be one of the coordinating members of the "CSIR-DST E-Journals Consortium" representing the DST Libraries. She continues to be in the editorial board of "Science & Technology Libraries" published quarterly in by Taylor & Francis Group. was invited as a member of the expert panel of the IIT Archives cell at Kanpur in April 2008.

S. Giridhar has been serving as President of the "International Astronomical Union", Commission 45 on "Spectral Classification" for the trimester 2006 – 2009.

A. Goswami coordinated the Kodai school on "Synthesis of elements in stars" held at Kodaikanal Observatory during April 29 – May 13, 2008; As a member of Board of Graduate studies, IIA, Bangalore, Goswami conducted IIA's Ph D examination at Gauhati University on December 13, 2008 as a coordinator from IIA.

S. S. Hasan is the Principal investigator of a DST-DAAD International Programme with the Kiepenheuer Institute, Freiburg, Germany on "Dynamics and Heating of the Magnetized Chromosphere". He was Chair, SOC, of the Evershed Centenary meeting "Magnetic Coupling between the Interior & Atmosphere of the Sun", 2–5 December, 2008, at IIA, Bangalore. He inaugurated the IYA meeting *Universalising the Universe* at IIA, Bangalore on April 4, 2008, 2nd IIA-Penn State Astrostatistics School at VBO, Kavalur on July 9, 2008 and the New Library of the Goethe-Institute, Max Mueller Bhavan, Bangalore on March 6, 2009. He delivered the vote of thanks at the programme that IIA organized jointly with RRI and NCBS at NIAS on Sept. 5, 2009 to felicitate Prof. M. G. K. Menon on his 80th birthday.

R. Kariyappa was appointed as a Member of Board of Examiners for M.Sc. (Physics: Astrophysics) exams of 2008-09 by Bangalore University and served as an external examiner at the Department Physics, Bangalore University for M.Sc. Physics/Astrophysics.

S. Mathur is a Member of the AsteroFLAG team as a young scientist since January 2009. AsteroFLAG is an international group that works on simulations of stars to improve and test asteroseismic codes.

K. N. Nagendra continues to be a Scientific Organizing Committee Member of Comm. 36 of IAU, on "Stellar Atmospheres", with a 2nd elected term of 3 years. He is also serving as a Member of the SOC of the Joint Discussion 10 (JD10) to be held, during the XVII General Assembly of IAU, 3 – 14 August, 2009 at Reo De Janeiro, Brazil. At the national level, he is a "Member of the Indian Physics Association".

P. Prabahar & B. S. Mohan are members of the "Karnataka State Library Association" which is an association for library and information professionals.

T. P. Prabhu served on the Scientific Advisory Committee of IUCAA (till 31 December 2008) and Scientific Advisory Committee of ARIES (also till 31 December 2008). He is a member of NCRA Management Board, ARIES Devasthal Optical Telescope Project Management Board, and GMRT Time Allocation Committee.

B. R. Prasad is a Member, DST (TSG) PAC & PRC, Expert Group on Molecular Electronics, conducting polymers, Non-invasive and other bio-sensors.

K. E. Rangarajan was the convenor for the "Summer School in Physics" which was held from June 9 – 21, 2008.

E. Reddy is the national coordinator for the proposed India's participation in the international Giant Segmented Mirror Telescope projects.

S. K. Saha continues to be a Member of the Editorial Board, "Asian Journal of Physics". He is also a Member of the Editorial Board, "Bhavishya Journal of Engineering Research". He continues to be the Member of the "Project Appraisal & Review Committee (PARC) of a project on 'Design & Development of Adaptive Optics System for Missile Imaging & Tracking and Long Range Surveillance", Instruments Research & Development Establishment (IRDE), Defence Research & Development Organisation (DRDO), Dehra Dun, India. He is a Member, "Pondicherry University School Board". He also acted as an advisory board member for an international conference on "Trends in Optics and Photonics (IConTOP)" held at Kolkata during 1 – 4 March, 2009.

M. Sampoorna is a Member of the "Indian Lindau Alumni group", co-ordinated by the DFG office at New Delhi.

P. Shastri is a Member of the IAU Organising Committee, Division X - Commission 40 - Radio Astronomy (2006 – 2009); Member, SOC, ASI (2007 – 2009); Member, Board of Studies, Physics Department, St. Agnes College, Mangalore (2007-). She organised IIA-PennState Astrostatistics School.

K. Sundara Raman was nominated member of the Board of Studies, Mother Teresa University, Kodaikanal and framed the syllabus for B. Sc., M. Sc., and M. Phil courses during April 2008.

6.9 Awards and Recognition

G. R. Gupta was awarded the best poster presentation in the 27th Astronomical Society of India meeting, in Sun and Solar System discipline. The poster was titled *On the statistical detection of propagating waves in polar coronal hole.*

S. S. Hasan, since 1991, is an Associate of the Harvard College Observatory, Cambridge, U.S.A. He is a Distinguished Adjunct Professor, Centre for Astroparticle Physics, Kolkata; Chair, Executive Council, Visheshwara Technological Museum, Bangalore; Membership of following Governing Councils: ARIES, Nainital; Bose Institute, Kolkata; IUCAA, Pune; National Council of Science Museums; Poorna Prajna Institute of Scientific Research, Bangalore; Member Board of Management, Centre for Theoretical Physics, Jamia Millia Islamia University, New Delhi; Member of the Scientific Advisory Committee of the Centre for Astroparticle Physics, Kolkata; Elected President of the Oxford and Cambridge Society of Bangalore and the Alexander von Humboldt Association of Bangalore. Elected member of the Organizing Committee of IAU Commission 10; Elected member of the International Committee of the Royal Astronomical Society, U.K.; Member of the editorial board of Solar Physics and Journal of Astrophysics and Astronomy.

The paper titled: *Fluorine in R Coronae Borealis Stars* by *Gajendra Pandey, David L. Lambert, N. Kameswara Rao* won the award as the best paper at the 27th ASI Meeting, held at Bangalore.

S. Mathur has been awarded the prestigious Chandrasekhar Post-Doctoral Fellowship of IIA.

C. Sivaram's paper has received 'Honourable Mention' in the essay competition of Gravity Research foundation (Massachussetts, USA) for the year 2008, for his essay titled *OJ 287 : New testing ground for general relativity and beyond.*

C. Sivaram's paper *Curvature, Phase Space, Holography and Black Hole Entropy* with **Kenath Arun* was awarded Honourable Mention in the 2009 competition of the Gravity Research Foundation, Massachusetts, USA. He also received "Vocational Excellence Award" from Rotary Club Bangalore South.

6.10 Collaborations

National Collaborations

1. IIA is collaborating with ISRO, Inter University Center for Astronomy and Astrophysics (IUCAA), Physical Research Laboratory (PRL), and Tata Institute of Fundamental Research (TIFR) to develop UltraViolet Imaging Telescope (UVIT), which is one of the payloads on satellite Astrosat.

2. IIA has set up a Gamma Ray Telescope array at IAO, Hanle, in collaboration with TIFR. The telescope design and development (mechanical, civil and control electronics) is implemented by IIA, while the Software for the telescope control and Data Acquisition System are developed by TIFR. The complete array of 7 telescopes is operational from August 2009. Observations and data collection from several objects have been obtained.

International Collaborations

1. Collaboration between IIA and INPE, Brazil: Observations of the Sun and strong radio sources at 1.6 GHz using 5 element interferometer at Cahoreia Paulista, Brazil were continued. A 1444 channel correlator system will be developed at IIA for the final phase of the BDA which will consist of 32 parabolic dishes of 4 m in diameter operating in the band 1.5 - 5 GHz with maximum baselines of 2 km.

2. TAUVEX mission, an Indo-Israeli ultraviolet imaging experiment that will image large parts of the sky in the wavelength region between 140 and 320 nm and is expected to be launched as part of the next GSLV mission (GSAT-4) soon.

3. A radio spectrograph for observations of transient burst emission from the sun in the frequency range 45 – 450 MHz developed in collaboration with the Institute of Astronomy, ETH, Zurich under the UN Basic Space Science Initiative (UNBSSI) programme is in operation at the Gauribidanur observatory.

6.11 Welfare of SC/ST Staff

A senior officer of the Institute is functioning as the Liaison Officer for the SC & ST staff members. Several welfare measures have been undertaken for staff members belonging to these categories in support of their careers and other aspects. The staff strength of the Institute as on March 31, 2009 was 327. 48 persons belong to SCs and 28 persons belong to STs, forming 17.8% and 9.96%, respectively, of the posts for which the reservation orders are applicable. In addition, reservations have been extended to OBCs and physically challenged persons.

6.12 Official Language Implementation

This year has been a remarkable year of achievements in connection with the compliance of Official Language implementation. More emphasis was given on Section 3 (3) of Official Language Act and as a result all the circulars, tender notices, advertisements forms etc were made bilingual. Administrative and other reports are also bilingual. These include the Institute's annual report and other administrative reports. Letters received in Hindi are replied to in Hindi.

Hindi Week was celebrated from 22–27 September, 2008. Four Hindi workshops were conducted for the administrative staff which resulted in a great increase in Hindi correspondence. Hindi books worth Rs. 15,503/- have been purchased for Hindi Cell during the year and reached the target of 50% as per Annual Programme of Official Language issued by the Dept. of Official Language, Govt. of India. Saransh Hindi software has been installed on 20 computers of IIA Bangalore Office to enable staff members to get themselves trained and work in Hindi.

The Hon'ble Second Sub-Committee of Parliament on Official Language inspected the Institute on 03.10.2008. The Hon'ble Committee was satisfied with the work being done in implementation of the Official Language. Three incentive schemes for staff have been introduced to encourage them to work in Hindi. Official Language Implementation Committee Meetings have been conducted regularly. Quarterly Reports are being sent to DST, New Delhi regularly.

Chapter 7

People

7.1 Staff List 2008 – 2009

Director : S. S. Hasan

7.1.1 Academic & Scientific staff

Senior Professor: B. P. Das, T. P. Prabhu, J. Singh, C. Sivaram

Professor : S. P. Bagare, H. C. Bhatt, S. Giridhar, J. Murthy, K. N. Nagendra, A. K. Pati, A. V. Raveendran

Associate Professor : G. C. Anupama, S. Chatterjee, R. K. Chaudhuri, R. T. Gangadhara, R. Kariyappa, S. G. V. Mallik, M. V. Mekkaden, B. R. Prasad, K. E. Rangarajan, K. P. Raju, S. K. Saha, P. Shastri, R. Surendiranath

Reader : D. Banerjee, J. Javaraiah, C. Muthumariappan, G. Pandey, S. P. Rajaguru, R. Ramesh, B. E. Reddy, S. K. Sengupta, A. Subramaniam, F. Sutaria

Scientist D : B. C. Bhatt, A. Goswami, K. M. Hiremath, U. S. Kamath, A. Mangalam, S. Muneer, P. S. Parihar, K. B. Ramesh, D. K. Sahu, A. Satyanarayanan, K. Sundararaman, M. S. Rao

Fellow : C. Kathiravan

Scientist C : R. K. Banyal, C. S. Stalin, B. A. Varghese

Scientific Officer SD : R. Mohan, L. Yeshwanth

Scientist B : P. Bama, E. Ebenezer, B. S. Nagabhushana, B. Ravindra, N. S. Singh

Research Associate : M. Appakutty

Distinguished Professor : R. Cowsik (Vainu Bappu Chair), V. K. Gaur

Adjunct Professor : A. R. Choudhuri, N. D. H. Dass, S. N. Tandon

Honorary Professor : J. H. Sastri, K. R. Sivaraman, R. Srinivasan

Visiting Professor : V. Krishan, N. K. Rao, K. R. Subramanian, P. R. Vishwanath

Consultant : D. C. V. Mallik, R. C. Kapoor

Visiting Scientist : V. Raju

Post Doctoral/Visiting Fellow : A. Borch, V. Das, P. Gopakumar, M. S. Luthra, S. Mathur, M. Safonova, A. P. Singh, N. V. Sujatha, N. Verma

Sr. Research Fellow : R. Chaudhari, G. Gupta, A. M. Karnataki, G. U. Kumar, B. Mathew, T. Mishra, K. Nagaraju, H. S. Nataraj, A. C. Pradhan, Ramya S., Sampoorna M., V. Singh, B. K. Y. Reddy, G. Vigeesh

Jr. Research Fellow : L. S. Anusha, Arya Dhar, Chandrasekhar, L. P. Chitta, Drisya, T. A. Ganesh, B. P. Hema, G. Indu, S. Krishnapradsad, D. Kumar, Rathna Kumar, Prasanth, P. Ramya, S. Rao, Roopashree, B. Reddy, A. Shukla, Sindhuja G., S. Subramanian, Vyas A.

Integrated Ph. D : R. Pandey, A. Prasad, M. Singh

IIA-CU M. Tech-Ph. D : C. Anantha, S. Arun, S. K. Dhara, K. S. Raja, N. V. Suresh, V. Vineeth

7.1.2 Technical staff

Engineer G : A. K. Saxena

Sr. Principal Scientific Officer : A. V. Ananth

Engineer F : M. S. Sundararajan

Engineer E : V. Chinnappan, G. Srinivasulu

Engineer D : V. Arumugam, S. S. Chandramouli, P. M. M. Kemkar, P. K. Mahesh, S. Nagabushana, B. R. Reddy, R. R. Reddy, F. Saleem, S. Sriram

Principal Scientific Officer : J. P. Lancelot, J. S. Nathan

Librarian : C. Birdie

Engineer C : P. Anbazhagan, D. Angchuk, S. Kathiravan, A. Kumar, K. C. Thulasidharan

Sr. Technical Officer : K. Jayakumar, K. Kuppuswamy, K. Rangaswamy, M. J. Rosario, J. P. A. Samson, A. Selvaraj, R. Selvendran

Technical Officer B : F. Gabriel, J. V. S. V. Rao, N. Sivaraj, K. S. Subramanian

Sr. Documentation Officer : S. Rajiva

Engineer B : K. Anupama, K. Dhananjay, T. Dorjai, S. Gorka, S. Jorphail, P. U. Kamath, T. T. Mahay, V. Selvi

Technical Officer : A. V. V. Kutty

Tech. Associate B : D. Babu, C. V. Sriharsha, Narasimhappa, S. Pukalenthi, G. S. Suryanarayana

Sr. Mech. Asst. C : A. Mani

Tech. Associate : P. Kumaravel, P. K. Mallappa A. Ramachandran, S. Ramamoorthy, M. R. Somashekar, S. V. Rao, K. Ravi

Draftsman E : V. K. Subramanian

Sr. Tech. Asst. B : A. P. Balakrishnan, R. I. Jabillullah, J. Manoharan, A. Muniyandi, T. K. Muralidas, M. Nagaraj, V. Ponnurangam

Tech. Asst. C : V. Gopinath, M. G. Mohan

Asst. Librarian A : B. S. Mohan, P. Prabahar

Project Consultant : A. Vagiswari

Consultant : K. Chandar, N. N. Gowda, R. C. Kapoor

Consultant Engineer : M. N. Karthikeyan, B. S. Nataraju, M. N. Rao

Visiting Project Associate : N. Jayavel

7.1.3 Administrative staff

Administrative Officer : A. J. Ragupathy

Dy. Administrative Officer : S. Rajasekaran

Personnel Officer : A. Narasimharaju

Staff Officer : K. Thiyagarajan

Accounts Officer : M. P. Parthasarathy

Sr. Asst. Administrative Officer : K. Mohan Kumar, Ramaiah

Asst. Administrative Officer : Y. K. R. Iyengar

Asst. Accounts Officer : G. R. Venugopal

Stores Officer : D. Lakshmaiah

Sr. Section Officer : L. Josephine, Meena, P. Mohan, A. P. Monnappa, K. Sutherson

Section Officer : N. Murthy, S. Rajendran, S. B. Ramesh

Sr. Office Superintendent : S. T. Devi, U. Maileveloo, G. A. Mary, A. P. Monnappa, R. M. Paulraj, N. K. Pramila, M. G. C. Nair, K. Padmavathy, M. Rajan, N. Sathya Bama, A. Veronica

7.2 Visitors to IIA

Feb – April, 2008
Zafar Turakulov
Ulug Bek Astronomical Institute
Uzbekistan

April 3 – 10, 2008
A. Grandpiere
Konkoly Observatory
Budapest, Hungary

April 7 – 12, 2008
Dirk Soltau
Kiepenheuer-Institute fur Sonnenphysik
Frieburg, Germany

April 13 – May 2, 2008
Simon Jeffery
Armagh Observatory
College Hill, Northern Ireland

April 26 – May 2, 2008
Amanda Karakas
Mt. Stromlo Observatory
Canberra, Australia

May 2 – 9, 2008
H. S. Sawant
INPE, Brazil

May 10 – 17, 2008
Katharina Lodders
Washington University
St.Louis, USA

May 12 – 17 2008
Bruce Fegley
Washington University, St. Louis, USA

May 17 – June 2, 2008
David Perez-Suarez
Armagh Observatory
College Hill, Northern Ireland

May 29 – 30, 2008
Roger Blandford
Kavli Inst. of Particle Astrophysics & Cosmology,
Stanford University, USA

June 12 – 13, 2008
Ritaban Chatterjee
Boston University, USA

June 13 – 20, 2008
Luca Teriaca
Max Planck Institute for Solar System Research
Germany

June 19, 2008
A. R. Ganesan
IIT, Madras

June 23 – 26, 2008
John Hutchings
Dominion Astrophysical Observatory
Victoria BC, Canada

June 24 – 27, 2008
Dipak Munshi
Institute of Astronomy
Cambridge, UK

26 June 2008
Chiranjib Sur
Ohio State University, Columbus, USA

08 July 2008
Shrinivas Kulkarni
California Institute of Technology, Pasadena, USA

July 4 – 8 2008
Claudio Ricci
Data Centre for Astrophysics, Geneva University,
Switzerland

July 17 – 18, 2008
Benjamin Trakhtenbrot
Tel-Aviv University
Ramat Aviv, Israel

July 31 – August 8, 2008
Ashish Mahabal
California Institute of Technology
Pasadena, USA

11 August 2008
C. N. R. Rao
Jawaharlal Nehru Centre for Advanced Scientific Research
Bangalore

12 August 2008
Claude Nicollier
Ecole Polytechnic Federale de Lausanne
Switzerland

12 August 2008
Monica Valluri
University of Michigan, Ann Arbor, USA

26 August 2008
Dipak Munshi
Institute of Astronomy, Cambridge, UK

September 15 – 20, 2008
Manas Mukherjee
Indian Association for the Cultivation of Science, Kolkata

October 1 – December 31, 2008
Shravan Hanasoge
Stanford University, Stanford, USA

October 2 – 4, 2008
Patrick McCarthy
Carnegie Observatories
Pasadena, USA

October 4 – 11, 2008
Tapas K. Das
Harishchandra Research Institute
Allahabad

October 31 – November 08 2008
Mausumi Dikpati
National Center for Atmospheric Research
Boulder, USA

November 26 – 29, 2008
Sami Dib
Service d'Astrophysique
CEA, Saclay, France

November 4 – 5, 2008
Jayaram Chengalur
NCRA, Pune

November 5 – 13, 2008
Inwoo Han
Korea Astronomy & Space Science Institute Daejeon
Korea

November 6 – 11, 2008
N. Kappelmann
Institut für Astronomie & Astrophysik
University of Tübingen
Germany

November 13 – 15, 2008
Phil Charles
South African Astronomical Observatory
Cape Town, South Africa

November 16 – 7 December, 2008
Hamed Moradi
Monash University
Melbourne, Australia

November 18 – 24, 2008
T. A. Ryabchikova
Institute of Astronomy
Russia Academy of Sciences
Moscow, Russia

November 24, 2008
Mikhail Sachkov
Institute of Astronomy
Russia Academy of Sciences
Moscow, Russia

November 22 – 6 December, 2008
Eamon Schullion
Armagh Observatory
College Hill, Northern Ireland

25 November 2008
Paola di Matteo
Observatory of Paris, Meudon, France

03 December 2008
Douglas Gough
University of Cambridge, UK

December 16, 2008
Alain Omont
Institute of Astrophysiqe De Paris, France

December 15 – 18, 2008
Raymond Bishop
University of Manchester, UK

17 December 2008
Bhimsen Shivamoggi
University of Central Florida
Orlando, USA

December 18 – 28, 2008
Oskar Steiner
Kiepenheuer Institute Sonnenphysik, Frieburg
Germany

November 29 – December 26, 2008
Jan Olof Stenflo
Swiss Federal Institute of Technology, Zurich
Switzerland

January 5 – 11, 2009
Vikram Soni
National Physical Lab
New Delhi

06 January 2009
Rahul Shetty
Harvard-Smithsonian Center for Astrophysics
Cambridge, USA

13 January 2009
Dhrubaditya Mitra
Queen Mary College, University of London
London, UK

15 January 2009
B. S. Chandrasekhar
Walther-Meiner-Institut
Garching, Germany

January 15 – 29, 2009
Dimitar Sasselov
Harvard Smithsonian
Centre for Astrophysics
Cambridge, USA

23 January 2009
Anil Pradhan
Ohio State University
Columbus, USA

January 23 – February 5, 2009
W. Kalkofen
Harvard Smithsonian Center
for Astrophysics, Cambridge, USA

January 23 – 27, 2009
Karen J. Meech
University of Hawaii
Honolulu, USA

January 26 – February 1, 2009
Jaroslaw Kijak
Institute of Astronomy
University of Zielona Gora
Poland

January 26 – February 10, 2009
Robert J. Rutten
Sterrekundig Instituut Utrecht
The Netherlands

February 2 – 12, 2009
Luca Teriaca
Max Planck Institute for Solar System Research
Germany

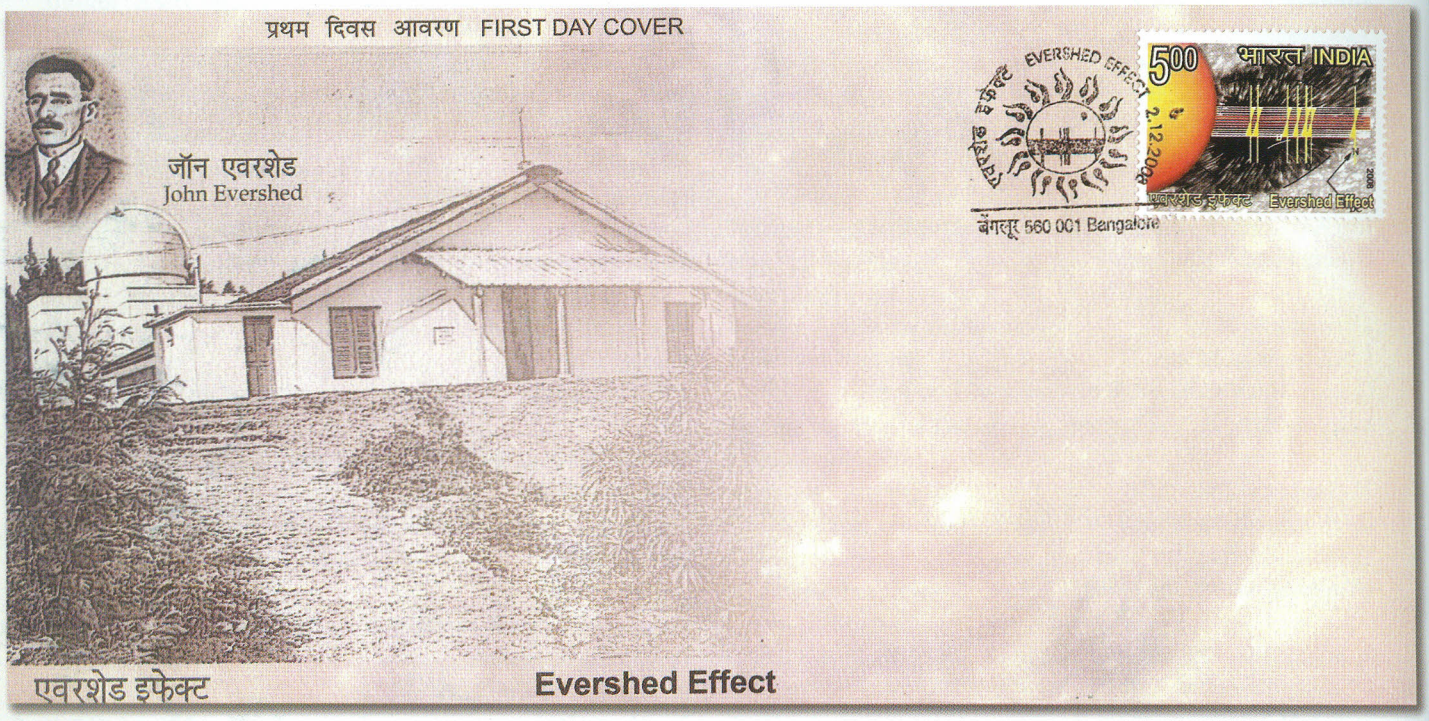
February 16 – 18, 2009
Loren Acton
Montana State University, USA

March 2 – 5, 2009
Varsha Chitnis
TIFR, Bombay

March 12 – 14, 2009
R. Rajaraman
Jawaharlal Nehru University
New Delhi

March 26 – April 10, 2009
David Perez Suarez
Aramagh Observatory
Northern Ireland

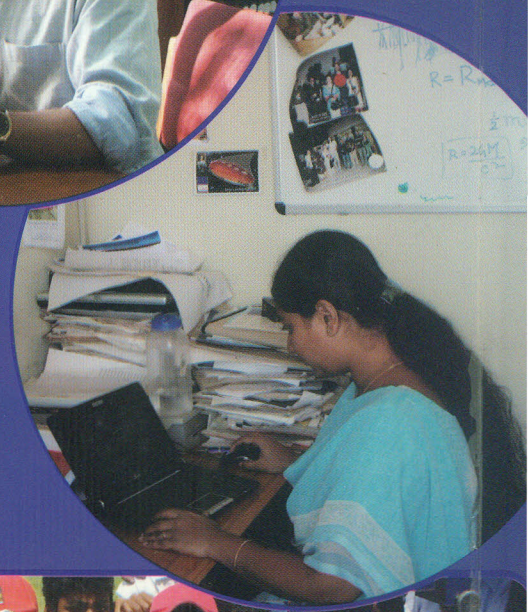
March 27 – 31, 2009
M. R. Kundu
University of Maryland, USA



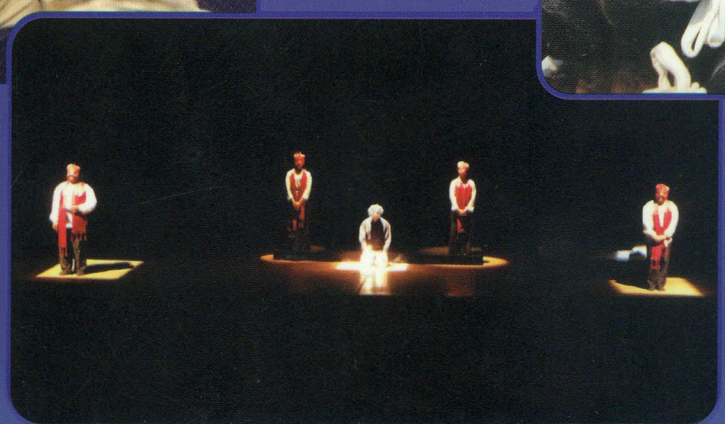
First day cover and stamp commemorating the centenary of the Evershed Effect discovery, released by the Chief Post Master General of Karnataka State on 2nd December, 2008.


विज्ञानऔर प्रौद्योगिकी विभाग
विज्ञानऔर प्रौद्योगिकी मंत्रालय
भारतीय खगोल विज्ञान


ಈ ಎರಡೂ ಗೋಲಗಳು ಒಂದೇ ಸಮಯದಲ್ಲಿ
ಭೂಮಿಯನ್ನು ತಲುಪುತ್ತವೆಯೆ ಎಂದು
ಗೆಲಿಲಿಯೋ ಕೇಳಿದನು.
ಪೀಸಾ ನಗರದ
ಓಲು ಗೋಪುರ




ANCIENT ASTRONOMY



IAU