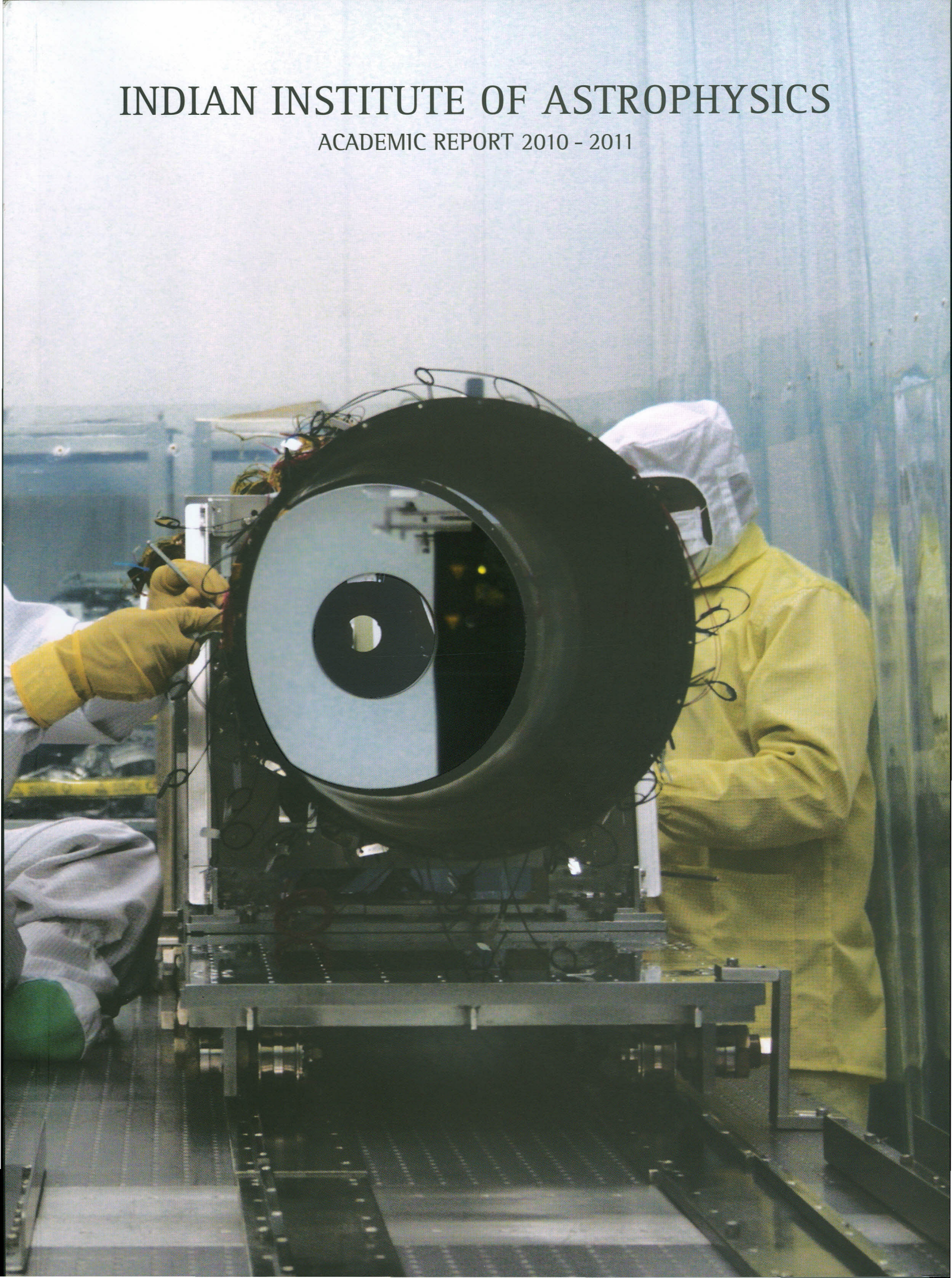
INDIAN INSTITUTE OF ASTROPHYSICS

ACADEMIC REPORT 2010 - 2011



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†*deceased*

The Year in Review

It is with immense pleasure that I summarise the activities of the Institute over the past year, which once again have been a rich mix of highly productive scientific research, developmental efforts and teaching in multiple programmes, in addition to conferences and other events on a wide range of topics for both the specialist and the public.

A highlight of Solar physics activity was observations of a total solar eclipse for the second year in succession, this time observed from the Polynesian island of *Rapa Nui*, or Easter Island in the Pacific. On the computational side, three new efficient numerical methods were developed to solve the polarized line transfer equation with angle-dependent PRD function, and the classical theory of PRD was generalised for atomic transitions with arbitrary quantum numbers. From an analysis of the linearly polarised (Second) limb solar spectrum, it was demonstrated that weak vector magnetic fields in the solar chromosphere can be investigated by combining the forward scattering Hanle effect near the disk centre with the longitudinal Zeeman effect. Using a new technique to solve the three-dimensional radiative transfer equation, the scattering matrix for quantum interference in the presence of arbitrarily strong magnetic fields has been derived.

High-cadence spectropolarimetry of sunspots has shown that the helioseismically measured travel times receive direction dependent contributions from acoustic waves, and found evidence for acoustic wave sources beneath the umbral photosphere. An analysis of the travel times along the wave path in an active region suggests that structural perturbations are largely confined to the near-surface layers. From an analysis of digitized photoheliograms from the Kodaikanal Observatory it was found that the dynamic behaviour of the sunspot penumbral area relative to its umbral area depends on the ambient magnetic field configuration and on the structure of the sunspot itself. From identification of rotational lines of the AlH molecule in sunspot umbral spectra, the rotational temperature was estimated to be approximately 3800 K. Doppler imaging of the sites of network regions near the disc centre of the quiet Sun showed that the nature of the interaction of acoustic waves with the small-scale magnetic fields of the quiet sun was similar to that of large-scale magnetic fields in the active regions. Analysis of time-sequenced ultraviolet images from the TRACE (Transition Region and Coronal Explorer) mission show intensity oscillations with periods of a few hours, suggesting that they may be related to the solar atmospheric gravity modes. Results from an analysis of quasi-periodic intensity variations of polar plumes using SoHO (Solar and Heliospheric Observatory) imaging are suggestive of the variations being magneto-acoustic waves rather than quasi-periodic high speed upflows. General solutions of non-linear force-free magnetic fields assuming spherical geometry were applied to vector-magnetograms of active regions obtained from Hinode, and the variation in energy and relative helicity for the active region as a function of time was derived. Fabry-Perot interferometric determination of the profiles of the coronal green line show secondary components at velocities between 20–40 km/s, suggesting that they are due either to type II spicules or the nascent solar wind flow. An analysis of extreme ultra-violet emission lines from the solar network region has shown that the intensities, Doppler velocities and linewidths are enhanced in the network region. Detailed theoretical investigations were carried out using three-dimensional magneto-hydrodynamic simulations to study the dynamics of magnetic fields in the network. In order to determine the dependence of radiative losses on the properties of the fluid, a model for solar granules has been developed. From analysis of sunspot group activity over a century, it is suggested that the decay of spot groups may enhance the energy output, and therefore contribute to the correlation between total solar radiance and sunspot activity. Analysis of the chromospheric velocity structures using spectropolarimetric data shows possible signatures of interaction between the plage magnetic fields and the overlying fields. A study of SoHO ultraviolet images suggests that coronal holes probably originate below the base of the convection zone and that they rotate rigidly. Weak low radio frequency bursts with intermediate brightness temper-

ature were found to have no accompanying activity in Hα and X-rays, and the total energy of their non-thermal electrons was found to be much weaker than the corresponding values for hard X-ray microflares. Using the diffraction pattern created by the moon's limb passing across the solar disc during a solar eclipse, the smallest sized discrete radio source in the corona known to date was discovered.

Andre Béteille, who delivered IIA's Bicentennial Commemorative Lecture.

In the area of stellar physics, intra-day variablity of the Hα profiles of pre-main sequence stars was seen, and the results were found to be most consistent with dynamic magnetospheric accretion and a disc wind. Differential multi-epoch photometry of the globular cluster NGC 6981 has yielded several new variables and enabled estimation of the physical parameters of the cluster. The triggered star formation scenario has been investigated using numerical simulations and the clump mass spectrum has been derived. A new Hydrogen-deficient carbon star has been discovered by IIA's Himalayan Chandra Telescope. Oxygen abundances from near-infrared spectra of Carbon-enhanced metal-poor stars from the Keck telescope suggest that the oxygen-enhancement could be due to a massive stellar wind or hypernovae pollution. 15 new Lithium-rich giant stars have been discovered using a spectroscopic survey with the VBO telescopes and HCT. V-band polarimetry of carbon-enhanced metal-poor stars suggest that the observed polarisation is due to circum-stellar grain scattering. Lithium abundances of stars in the α Persei cluster from high spectral resolution measurements suggest that the star-to-star spread in the abundance develops after about 20 Myr. Photometry and spectroscopy of the recurrent Nova U Scorpii suggest matter ejection at velocities of 10,000 km s-1 and rapid variation on time-scales of an hour. An investigation of the supernova SN 2009jf showed evidence for an explosion with large kinetic energy. A relativistic pulsar emission model that accounts for aberration and retardation was found to explain the observed range of circular polarisation and position angle swing. Ultra-violet halos have been found for the first time around the stars Spica and Achernar, due to starlight scattered by thin dust clouds near the star. A long-term multi-epoch campaign with VBT and HCT to search for intermediate-mass black holes at the centres of globular clusters via their microlensing events has begun, and has resulted in ia the by-product discovery of several variable stars in the cluster NGC 5024.

G. Padmanaban accompanied by Siraj Hasan, Director, garlanding the bust of Vainu Bappu on August 10, 2010 on the occasion of Founder's Day.

In the area of extragalactic astrophysics, the structure of the Large Magellanic Cloud was investigated using its red clump stars, which imply structural warps in the LMC and suggest tidal effects. Multi-frequency observations of blue compact dwarf galaxies have shown evidence for recently triggered star formation, stochastic self-propagating star formation and highly extended HI discs. Spectroscopy of low surface brightness galaxies have yielded central black hole masses that are in the intermediate black hole mass range. The well-known blazar Mkn 421 was detected by the HAGAR telescope in a flare state. Metallicities of the Bootes I dwarf spheroidal galaxy imply that such systems could have been contribu-

tors to the Galactic halo. Spectral fits to the X-ray emission and radio imaging of active galaxies of the Seyfert type that were carefully selected to be intrinsically similar but spanning large range of orientations, yielded systematics of X-ray and radio luminosities, line-of-sight absorption and emission-line strengths that indicate axisymmetric obscuring material in their nuclei. Quasars with broad absorption troughs in their ultraviolet spectra were found to have systematically lower X-ray luminosities than ordinary quasars. The mass of the central black hole in a Seyfert galaxy was derived by applying the reverberation mapping technique to multi-epoch data from HCT. A lower limit on the mass of the central black hole has been derived by modeling the variability of the active nucleus. The energy index of relativistic electrons in distant galaxies can be accounted for by redshifted synchrotron losses and do not need Fermi acceleration processes.

School children at a day-time astronomy workshop at the Kalpaneya Yatre astronomy festival.

In the area of atomic and molecular physics, a relativistic coupled-cluster calculation was performed for the first time using three and four particle excitations which, when applied to the Al^+ atomic clock, reduces systematic errors by 28%. Investigation of the quantum phases of ultracold bosonic atoms using the density matrix renormalization group have shown that the Mott insulator co-exists with the superfluid phase at an incommensurate density.

A new limit for the electron dipole moment (EDM) has been derived by combining the measured EDM of thallium with the ratio of atomic to electron dipole moments that was derived by applying the relativistic coupled-cluster theory to atomic thallium. The ionization potential, excitation energies and oscillator strengths of the Indium atom that were computed using the valence universal coupled cluster method were found to be in excellent agreement with experimental data. The hyperfine structure constants for the BaF molecule were calculated by applying the many-body perturbation theory via the Z-vector technique and were found to be good agreement with experimental determinations.

In the area of optical sciences, the cross talk induced by atmospheric seeing between the measured Stokes parameters of the solar emission line profiles, which impacts the derivation of the surface magnetic fields of the sun, was studied using the Lites formalism. Numerical simulations suggest that the prediction of wave front arrival by pixel-wise prediction of phase screens and slope extrapolation techniques are equally effective, while modal prediction can yield improved results. In order to increase the fidelity of images from high-resolution CCD cameras using microelectromechanical systems, experiments in noise reduction were conducted and it was found that using intensity-weighted noise removal significantly improved the image quality. The extended matched filter method was shown to enable the detection of periodic structures hidden in rough surfaces, which conventional methods bound by the usual Rayleigh criterion would fail to reveal. It has been demonstrated theoretically and experimentally that the dual-energy computed tomography inversion algorithms must use the full Klein-Nishina formula for the Compton scattering and the correct exponents for the photoelectric effect.

On the developmental front, the infrastructure for the installation of the 1.3m telescope at the Vainu Bappu Observatory in 2012 is in full swing, as is the site-characterisation effort for the proposed 2m class National Large Solar Telescope (NLST) in the Himalayas. NLST will be a unique state-of-the-art telescope for carrying out high-resolution studies of the Sun. A comprehensive design study has been carried out and a Detailed Project Report has been produced. A major activity in the MGK Menon laboratory at IIA's Hosakote campus has been the assembly and testing of the Ultra-violet Imaging Telescope (UVIT) payload to be launched on the ASTROSAT space astronomy mission next year. In addition, work commenced on various new programmes that include the development of a high-resolution Echelle spectrograph for the HCT, a 20cm space coronograph on Aditya I and India's participation in the mega-international Thirty-Metre Telescope project.

IIA's new teaching programmes have continued, with the first batch of students from both the M.Sc.-

Ph.D. and M.Tech.-Ph.D. programmes completing their Masters degrees (M.Sc. and M.Tech. respectively). IIA also hosted four students from the United States, who did research projects in IIA under the *International Research Experience Programme* funded by the National Science Foundation, USA.

IIA's outreach activities reached new heights this year by building upon the collaborations established during the International Year of Astronomy in 2009. IIA played a major role in an inter-institutional astronomy festival christened Kalpaneya Yatre, a first-of-its-kind event in Bangalore wherein IIA scientists were involved in the design of the exhibition, and also led the activities component of the festival. Both young and adult audiences were targeted by these activities, and amateur astronomers, science popularisers, artist-designers and theatre artistes were all brought together to lead different events, which included *Ask an Astronomer* sessions, astronomy workshops for teachers and for children, art and theatre activities, sky-watching events, besides lectures on various topics. These activities reached thousands of people, and ended with an inter-disciplinary one-day symposium on *Astronomy & Society: Public Ownership of Science*.

Roger Blandford, Robert Wald, Siraj Hasan and K. Kasturirangan at the Chandrasekhar Centenary Conference at IIA.

IIA organised several meetings during the year, including international ones. The 3rd IIA-PennState Astrostatistics school continued to be a big draw as in the previous schools, with participation by astrophysicists of all levels including PhD students and faculty, and including several participants from Europe and other countries. The 3rd Indo-China workshop on Solar Physics along with the first Asia-Pacific Solar Physics meeting served as an excellent platform to kick start several international collaborations. IIA hosted a Humboldt Kolleg on *Self-organized Criticality: The Dynamics of Complex Systems*, an inter-disciplinary conference supported by the Alexander von Humboldt Foundation, Germany. A highlight of the year was a conference to celebrate Chandrasekhar's birth centenary. The focus was on research areas in which Chandrasekhar made seminal contributions during his lifetime, and included several review talks by stalwarts in those areas.

Hans Meinhardt from the Max Planck-Institute for Developmental Biology in Tubingen, Germany, delivering the keynote address at the Humboldt Kolleg.

IIA hosted a wholesome blend of public lectures over the year that were extremely well received. India's leading sociologist and writer Andre Béteille gave the Bicentennial Commemorative lecture on *Can Rights Undermine Trust? How Institutions Work and Why they Fail.* IIA's Founder's Day which is celebrated on the birth anniversary of Vainu Bappu, had India's renowned biochemist, G. Padmanaban, deliver a lecture on *Growth of Biotechnology in India.* The fourth Vainu Bappu Memorial lecture with the title *What Makes Spiral Galaxies Tick?* was delivered by renowned astrophysicist James Binney from the University of Oxford. The International Womens' Day which this year occurred during the International Year of Chemistry, was celebrated with a public lecture and discussion on Dorothy Hodgkin, and this event served as a trigger for regular informal discussions through the year on a rich variety of topics, especially by students.

IIA's efforts on the implementation of the Hindi

language have gathered considerable momentum this year. The IIA newsletter has been carrying pieces written in Hindi. In addition to language workshops, there was enthusiastic participation by the staff in a variety of language-based cultural activities. The Institute continues to be proactive in building an equitable workplace by safeguarding the interests of SCs and STs as well as women.

James Binney being felicitated after delivery of the Vainu Bappu Memorial Lecture.

We are very proud of our PhD student K. Sowmya who emerged as the top-ranker of Bangalore University in 2010 in the MSc Physics course and was awarded six gold medals for her performance, our Ph.D. student Avijeet Prasad, who emerged third in the National Level CSIR-NET examination, and our documentation specialist Sandra Rajiva, who was facilitated at the meeting of the Astronomical Society of India for her 25 years of service to the Bulletin of the ASI.

Siraj Hasan
Director

Chapter 1

Research

1.1 Solar Physics

Total Solar Eclipse of July 11 2010 from Easter island, Chile

Figure 1.1: Indian eclipse team with (from left to right): J. Singh, K. Ravi. D. Banerjee, P. K. Kapoor (Indian ambassador to Chile), Siraj Hasan and F. Gabriel.

A team of scientists from the Indian Institute of Astrophysics, Bangalore set up camp at Easter Island in July 2010 and conducted several experiments during the total solar eclipse of 11th July. Easter Island, a triangle of volcanic rock islands in the south Pacific – best known for the giant stone monoliths called Moai, that dot the coastline, is over 3,700 km from the nearest population centre, (Tahiti and Chile), making it one of the most isolated places on Earth. The site was carefully selected to achieve the best observations in order to have a long duration of totality (4min 40sec). The path of the Moon's umbral shadow crossed the south Pacific ocean where it encountered a no-land mass except for Mangaia (Cook Islands), Easter Island (Isla de Pascua) and several isolated atolls. The path of totality ended just after reaching southern Chile and Argentina. The Moon's penumbral shadow produced a partial eclipse visible from a much larger region covering the South Pacific and southern South America. The team consisted of Siraj Hasan (Director), Jagdev Singh, Dipankar Banerjee, K. Ravi and F. Gabriel.(Figure 1.1)

The planned experiments were successfully carried out in good sky conditions. The major challenge in studying the line widths with chromospheric spectral lines is that the chromospheric spectra obtained on the disc have the inherent problem of integration of the signal along the line-of-sight. On the other hand, spectra obtained at the limb have scattered light which makes it impossible to study the variation in line profiles as a function of height and thus study the chromospheric heating. Thus total solar eclipses provide the best opportunity to get the uncorrupted chromospheric spectra as a function of height. During the first few seconds of the second contact of an eclipse, when the chromosphere is visible, with the availability of high speed CCD cameras with high photometric accuracy, it is possible to obtain spectra at high frequency of about 10 Hz.

Two experiments were performed by the IIA team. (1) Emission line Spectroscopy: A two-mirror coelostat with 10cm, f/10 objective, collimator & camera lens with 14cm aperture of 140cm focal length resulted an image size of about 9.1 mm, 210 arcsec/mm with dispersion: 2.095Å /mm. CCD cameras with 1Kx1K format (EM CCD), Pixel size: 13.5x13.5 microns, Read out: 14-bit at 10 MHz were used. Images were obtained at a frequency of about 1 Hz. The objective of the other experiment was to take Chromospheric spectra in the hydrogen-alpha line as a function of height at a high frequency of about 7 Hz. For this a two mirror coelostat system with 14cm objective of 12 m focal length yielded an image size of about -35cm with dispersion: 1.06Å/mm.

The image of the corona was taken with an SLR camera to provide the context. The Sun was in a

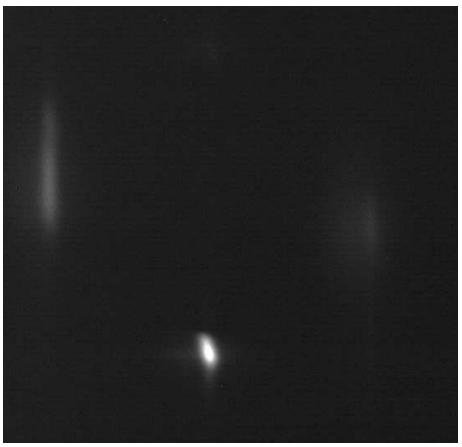

Figure 1.2: A representative multi-slit spectrum around the green emission line with 3s exposure. The central bright region may correspond to a jet-like structure at the solar limb.

Figure 1.3: A representative H-alpha image: A slit width of 300μ at the East limb of the sun was used with an exposure time of 126 ms at 7.1 Hz.

phase of minimum activity, so that the corona was more diffused and less structured. (Figure 1.4).

A combination of imaging and spectroscopy revealed a wealth of new information about the solar corona such as the presence of waves, that could be important for heating it to two million degrees. Along with this ground-based experiment from the Easter Island, the team also performed simultaneous observations from space using the Japanese satellite Hinode.

(The IIA Solar Eclipse Team)

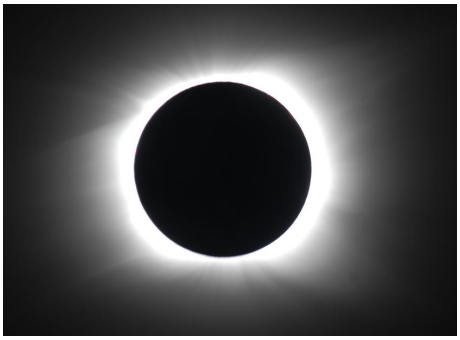

Figure 1.4: Image of the corona taken with a SLR camera.

Physics of angle-dependent partial redistribution

The Rayleigh scattering of solar limb darkened radiation field on atoms gives rise to the linearly polarized spectrum of the Sun. The linear polarization of strong resonance lines is very sensitive to the form of the Partial Frequency Redistribution (PRD) function used in the line radiative transfer computation. Observations have been analyzed until now using the angle-averaged PRD functions. With an increase in the polarimetric sensitivity, and resolving power of the telescopes, it will become possible to detect 'finer effects' caused by the angle dependence of the PRD functions.

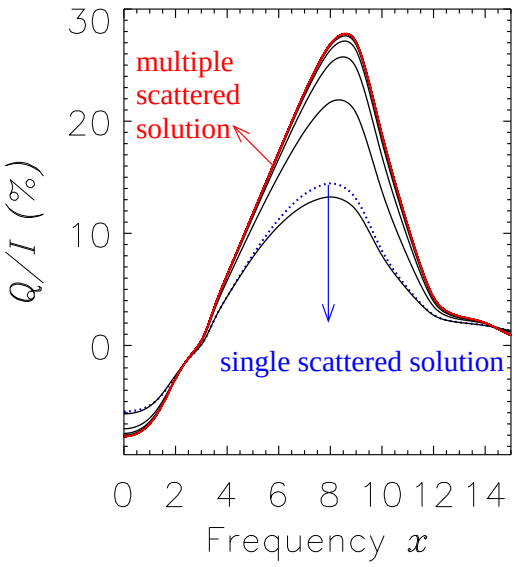

Figure 1.5: Convergence history of the degree of linear polarization (Q/I) for the SEM approach.

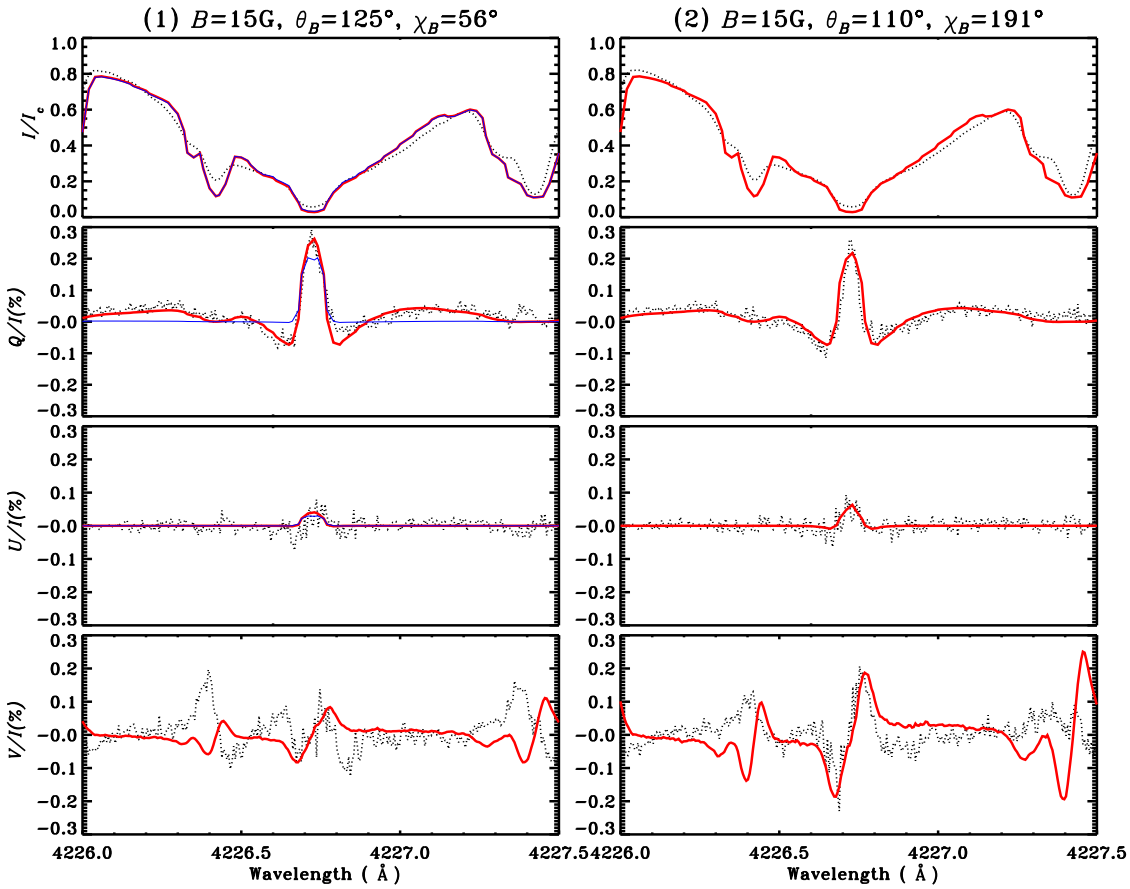

Figure 1.6: The best fit of the theoretical model profiles (solid lines) to the observed profiles (dotted lines) for two sets of observations. The theoretical Q/I, U/I profiles are computed from the Hanle effect and the V/I profiles from the weak field approximation of the Zeeman effect. In the left panels the thin solid lines represent the profiles computed under the assumption of complete frequency redistribution.

The difficulty in using angle-dependent functions in the polarized line transfer computation, stems mainly from the evaluation of the scattering integral, because these functions couple in an intricate way the directions and frequencies of the incident and scattered beams. Three new efficient numerical methods to solve the polarized line transfer equation with angle-dependent PRD function have been developed, using the recently formulated Stokes vector decomposition technique. Two of them are of the accelerated lambda iteration (ALI) type. The third method is based on a 'Neumann series expansion', and is referred to as the Scattering Expansion Method (SEM). The SEM is shown to be fastest of all (about 90 times faster than the ALI based method). Figure 1.5 shows the convergence history for the degree of linear polarization Q/I calculated from the SEM.

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

Analysis of the forward scattering Hanle effect in the Ca I 4227Å line

Coherent scattering of limb darkened radiation has been responsible for the generation of the linearly polarized spectrum of the Sun (the Second Solar Spectrum), which was usually observed near the limb of the Sun, where the polarization amplitudes are the largest. At the solar disk centre the linear polarization was zero for an axially symmetric atmosphere. Any mechanism that broke the axial symmetry (like

the presence of an oriented magnetic field, or resolved inhomogeneities in the atmosphere) can generate a non-zero linear polarization. The linear polarization near the disk centre (forward scattering polarization) in a weakly magnetized region was studied, where the axi-symmetry was broken. The polarimetric (I, Q/I, U/I, V/I) observations of the Ca I 4227Å line recorded around $\mu = \cos\theta = 0.9$ (where θ is the heliocentric angle) and a modeling of these observations have been presented.

From the above investigations it was demonstrated that the forward scattering Hanle effect (for observations near the disk centre), combined with the longitudinal Zeeman effect could be used as a good diagnostic of weak vector magnetic fields in the solar chromosphere. An illustration of the results of our modeling is presented in Figure 1.6.

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

Theory of partial frequency redistribution for J-state interference in the presence of a magnetic field

The Second Solar Spectrum (the linearly polarized spectrum) of the Sun is formed due to coherent scattering processes. It contains a number of multiplets like the Na I D_1, D_2 and Ca II H, K in which the linear polarization is influenced by the quantum interference effects. To understand these effects a partial frequency redistribution theory including the effects of J-state interference was developed, which is valid for magnetic fields of arbitrary strength. Using this theory, the effects of J-state interference were explored in a hypothetical doublet at 5000Å and 5001Å. The effects were found for different magnetic field strengths, wavelength separations between the doublets and also in the presence of a weakly polarized background continuum.

(K. N. Nagendra, H. N. Smitha, M. Sampoorna & J. O Stenflo)*

Polarized line transfer in multi-dimensional media

In the Stokes vector basis, solution of the polarized radiative transfer (RT) equation in multi-dimensional (multi-D) geometries was complicated because of non-linear couplings. A technique to decompose the Stokes vector (I, Q, U, V) in terms of the irreducible spherical tensors for polarimetry $\mathcal{T}^K_Q$ was developed. An RT equation in the irreducible Stokes vector basis was formulated. This reduced RT equation was more amenable to develop new numerical techniques of solution. In Anusha et al. (2011b), Stokes vector decomposition technique was applied to two-dimensional (2D) RT, and an efficient method based on projection techniques, known as the Pre-BiCG-STAB (Preconditioned Bi-Conjugate Gradient) method was developed. This method was used to solve the polarized RT equation with PRD in a 2D slab. The geometry of the problem is shown in Figure 1.7.

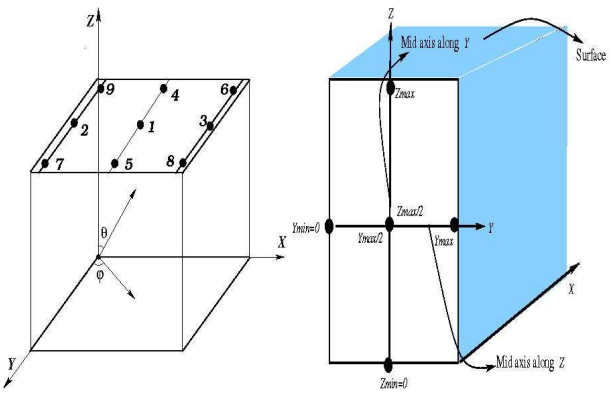

Figure 1.7: Figure showing the radiative transfer in 3D and 2D geometries.

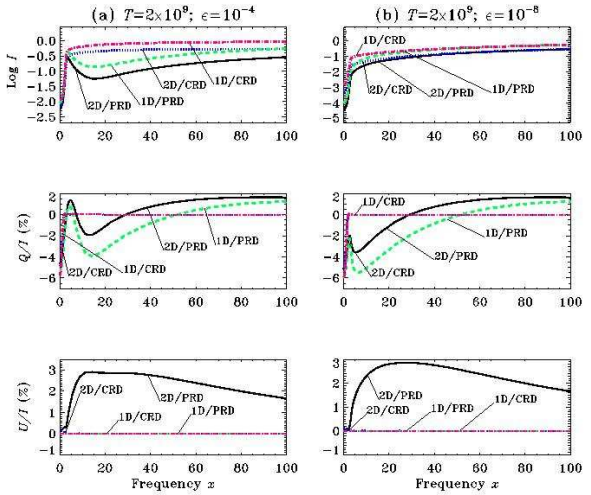

Figure 1.8: The differences between complete frequency redistribution and partial frequency redistribution effects on Stokes profiles formed in a semi-infinite 2D atmosphere. The results were shown for a ray emerging at $\cos\theta = \mu = 0.11$ and φ=60°. The 1D results were shown for comparison.

It was shown that the multipolar expansion for Stokes vector and Stokes source vector allowed to

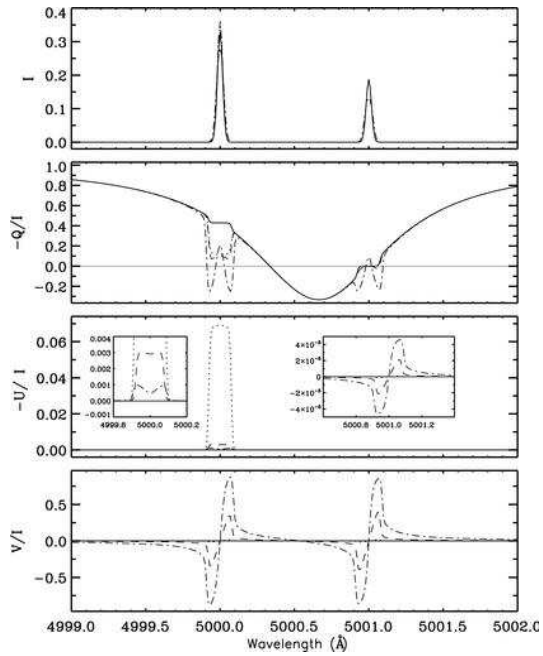

Figure 1.9: Stokes profiles for a hypothetical doublet at 5000Å and 5001Å, with magnetic field $B = 0\,\mathrm{G}$ (solid line), $B = 8.5\,\mathrm{G}$ (dotted line), $B = 214\,\mathrm{G}$ (dashed line), and $B = 1071\,\mathrm{G}$ (dash-dotted line).

write an RT equation in terms of I^K_Q and S^K_Q which was much easier to solve because of the reduced dependence of physical quantities on the angular variables. Due to symmetry breaking at the finite boundaries, the nature of the $(Q/I, U/I)$ spectra formed in 2D and 3D media differed significantly from the corresponding 1D cases (see Figure 1.8).

(L. S. Anusha, K. N. Nagendra & F. Paletou)

Theory of polarized line scattering including the quantum interference phenomena

The linearly polarized spectrum of the Sun is due to coherent scattering processes in which quantum interference (Q.I) phenomena plays a vital role. The polarization of Na I D_1, D_2 and Ca II H, K are the two famous double line systems which still remain unexplained. The quantum interference phenomenon arises due to interference between the fine structure levels (J-states). The scattering matrix for quantum interference in the presence of magnetic fields of arbitrary strength has been derived.

Figure 1.9 showed the effects of J-state interference for different magnetic field strengths in a hypothetical doublet separated by 1Å (5000-5001Å). The

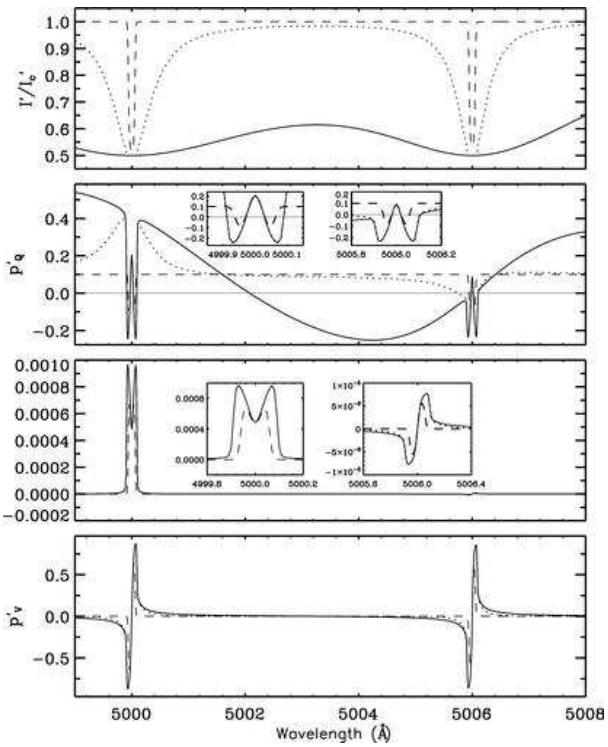

Figure 1.10: Same as Figure 1.9 but in the presence of a background continuum and a strong field $B = 1071\,\mathrm{G}$. Line types represented the effect of different values of the continuum with solid line showing the effect of weakest and dashed line showing the effect of the strongest continuum opacity.

polarization produced in a single 90° scattering experiment was shown. The signatures of J-state interference were seen in the Q/I profiles through two sign reversals – one in between the two lines and the other at 5001Å line. For strong magnetic fields ($B \sim 1000$G), interesting signatures were seen in U/I at 5001Å line, which could be explained from the J-state interference theory. Figure 1.10 showed the effects of a background continuum on J-state interference. As the strength of background continuum increased, J-state interference effects decreased.

(H. N. Smitha, M. Sampoorna, K. N. Nagendra, J. O Stenflo)*

Theory of polarized light scattering on atoms in arbitrary magnetic fields

The problem of atom-radiation interaction remains an important problem of quantum physics to this day. The problem of scattering of polarized radiation on atoms and molecules in arbitrary magnetic fields in particular, is a front-line topic in Solar physics,

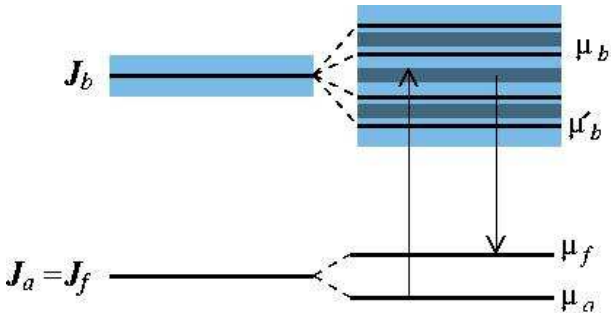

Figure 1.11: m-state interference phenomena (the well-known Hanle effect) in atomic transitions involving arbitrary J-states. The light shades represent the radiative widths of the levels, and the dark shades refer to the interference between them. The lower level was assumed to be infinitely sharp.

mainly due to the discovery of extremely rich structuring of the 'Second Solar Spectrum'.

The classical theory of partial frequency redistribution (PRD) that is applicable to a $J = 0 \rightarrow 1 \rightarrow 0$ scattering transition was generalized to handle other types of atomic transitions with arbitrary quantum numbers. The quantum interference between magnetic substates of a given upper J-state was taken into account (see Figure 1.11). The generalization was done in a phenomenological way, based on the direct analogy between the Kramers-Heisenberg scattering amplitude in quantum mechanics and the Jones scattering matrix in classical physics. The redistribution matrices derived from such a semi-classical PRD theory are identical to those obtained from a perturbative quantum electrodynamic treatment of the atom-radiation interaction. The semi-classical approach however has the advantage that it is non-perturbative, more intuitive, and lends itself more easily to further generalization (like the inclusion of J-state interference in the PRD theory).

(M. Sampoorna)

Stokes diagnostics of magneto-acoustic wave propagation

The highly dynamic solar photosphere is a rich source of waves, which are believed to be one of the plausible candidates responsible for heating the upper solar atmosphere. Recent observations and numerical simulations have motivated us to explore polarimetric signatures of such waves in magnetic networks on the Sun. We carried out a study of emergent spectra from data generated using magnetohydrodynamic numerical simulations. Our investigations of polarization signals of magneto-acoustic wave propagation in a photospheric magnetic flux concentration show that observational signatures of waves in magnetic elements can be observed only if the spatial resolution is high enough so that magnetic concentrations can be resolved into different regions within the flux concentration. We have highlighted the feasibility of using the Stokes-V asymmetries as a diagnostic tool to study the wave propagation within magnetic flux concentrations. Although the simulated Stokes asymmetries would be detectable with current polarimetric instruments, observations of considerably higher spatial resolution, capable of resolving individual flux concentrations, are needed in order to reveal the propagation of waves in individual flux concentrations and to detect the different modes of the MHD waves.

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

3-D simulations of magnetohydrodynamic waves in the magnetized solar atmosphere

Three dimensional numerical simulation of wave propagation in a magnetic flux tube embedded in a solar atmosphere were carried out. We investigated two types of excitation mechanism that mimic granular buffeting and vortex flows. These motions generates slow and fast magneto-acoustic waves in the medium, however, with different relevance. The observations of vortex flows in the photosphere and the corresponding chromospheric feature reveal that the bright points associated with the flux concentration follow a spiral path towards the center of the vortex. We belive that they are constantly buffetted by the granules on their way to the intergranular sink, resulting in a horizontal excitation of the flux-tube, generating slow (acoustic) waves which eventually dissipate due to shock formation and show up as emission in the chromosphere. But as these flux-tube approach the eye of the vortex, the horizontal excitation ceases and the flux-tube is mainly driven by a torsional motion, which generates negligible slow (acoustic) waves resulting in lesser shocks and hence weaker emission. We propose that more than one mechanism of wave production is effective during the excursion of magnetic element in the intergranular lane, and these results in temporal variation of the overall emission that occur at chromospheric heights over these magnetic elements.

(G. Vigeesh, V. Fedun, S. S. Hasan & R. Erdelyi*)*

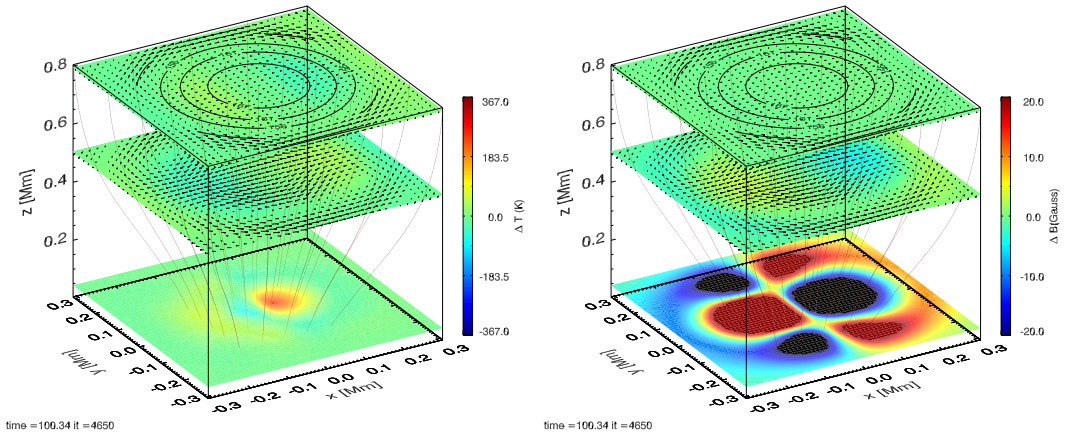

Figure 1.12: Temperature (left) and magnetic field strength (right) fluctuations in a flux tube at three different heights (30 km, 500 km and 900 km above the base of the photosphere) as result of a transverse uni-directional excitation. Field lines are shown to mark the flux tube. The contours of equal magnetic field strength at a height of 1 Mm are shown on the top.

Local helioseismic and spectroscopic analyses of interactions between acoustic waves and a sunspot

Using a high cadence imaging spectropolarimetric observations of a sunspot and its surroundings in magnetically sensitive (Fe I 6173Å) and insensitive (Fe I 7090Å) upper photospheric lines, instantaneous wave phases and helioseismic travel times have been mapped as a function of height (within the formation layers of the chosen lines) as well as of line of sight inclination of magnetic field. While confirming the magnetic inclination angle dependent transformation of quiet-Sun originating acoustic waves into propagating waves up through the sunspot atmosphere, it has been found that (1) the helioseismically measured travel times receive direction dependent contributions from such propagating waves and hence cause errors in conventional flow inferences, (2) there is evidence for acoustic wave sources beneath the umbral photosphere, and (3) there are significant differences in travel times measured from the chosen magnetically sensitive and insensitive spectral lines.

(S. P. Rajaguru, R. Wachter, S. Couvidat* & K. Sankarasubramanian*)*

Sunspot seismology: frequency dependences of travel times

Frequency dependence of mean travel times, i.e. average of travel times in opposite directions along a wave path, over a sunspot region, had been shown and interpreted by previous researchers as an indication of perturbations largely confined to a region not deeper than a few Mm. Here, the frequency variations of perturbations in in- and out-going travel times, $\delta\tau_{in}$ and $\delta\tau_{out}$, respectively, have been studied over the active region NOAA 9787 (observed during 20th – 28th January, 2002) for a travel distance $\Delta = 50$ Mm, and the following new features have been derived: (1) there was an asymmetry in the frequency dependences of $\delta\tau_{in}$ and $\delta\tau_{out}$: there was a marked depression in the variation of $\delta\tau_{out}$ in the frequency interval 3.5 – 4.5 mHz. Since a material flow would cause a symmetric and opposite change in in- and out-going times, the asymmetric (as a function of frequency) signals in travel time differences, $\delta\tau_{out}$-$\delta\tau_{in}$, were likely from some other physical causes. This had been tentatively identified as a helioseismic signature of well observed p-mode absorption of sunspots. (2) In comparison with those seen at smaller Δ, waves travelling larger distances (i.e. waves of smaller wave numbers), and hence deeper propagating ones, showed smaller variation with frequency. This was consistent with the variation of mode mass with frequency, and hence with the interpretation that structural perturbations are

largely confined to the near-surface layers.

(H. Moradi et al.& S. P. Rajaguru et al.)*

Impact of ambient magnetic bipolarity on properties of sunspots

In an earlier study of revisit of the classic Wilson Effect, it was found that a large proportion of sunspots did not display the geometric effect which was ascribed to a depression of the umbra. It was shown that the presence or absence of the effect, observed close to the limb, depended upon the ambient magnetic configuration of the sunspot. In this follow up study, the impact of changes in the ambient magnetic configuration on the measurable properties of sunspots, during their disk passage, was examined using observations obtained at the Kodaikanal observatory during 1978–80, the maximum phase of solar cycle 21.

Digitized photoheliograms were used to examine and measure areas of spots and their umbrae for 101 cases. Magnetic field measures published by the Academy of sciences, Leningrad were used to evaluate the ambient magnetic configuration. A magnetic bipolarity index Qs was defined as a measure of the strength and proximity of opposite polarity spots and strong pores. Figure 1.13 is a plot of the ratio of the area of spot penumbra to its umbra against Qs. Here the sunspots are represented with: asterisks - regular spots; hollow circles - spots with pore-sized blobs in penumbra (implying pore merger phase); solid circles - spots with light bridges or split umbrae.

It is evident that the relative area of penumbra showed a dynamic behavior which depended not only upon the ambient magnetic configuration but also on the structure of the sunspot itself. A detailed study of the behavior is being carried out with a much larger data set.

(S. P. Bagare)

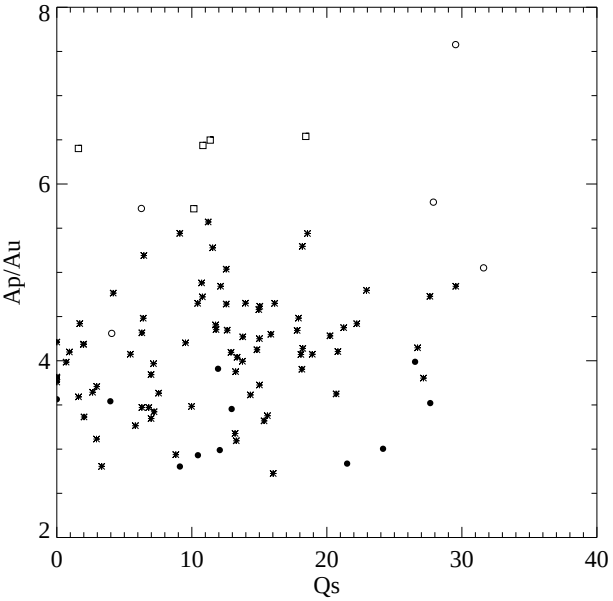

Figure 1.13: Ratio of the area of spot penumbra to its umbra vs. magnetic bipolarity index Qs for 101 cases. Symbols have been described in the text.

On rotational temperature of AlH in sunspots

A search was carried out for the presence of rotational lines of two bands of the A - X system of the molecule AlH, in the high resolution Fourier Transform Spectra of sunspots observed at the National Solar Observatory at Kitt Peak. Though the presence of AlH in sunspots was confirmed by Wallace, Hinkle and Livingston based on their Atlas of Sunspot Umbral Spectra in the visible region between 392 and 666 nm, there had been no report so far of the estimation of its rotational temperature.

In the present search, a new identification technique was used and this largely confirmed the earlier identifications. The effective rotational temperature was estimated for the (0, 0) band to be 3804 $\pm$ 1300 K. The large error was attributed to the blending by lines due to other transitions. It must be pointed out that the sunspot umbrae displayed a wide range of reported effective temperatures between 1500 and 5000 K. This fact had been demonstrated in the NSO atlas with spectra for hot and cold umbrae. One could therefore have spectra where specific bands were more pronounced, using more accurate temperature estimates.

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

Observational evidence of the interaction of acoustic waves and smallscale magnetic fields

The effect of magnetic fields on photospheric intensity and velocity oscillations at the sites of smallscale magnetic fields (SMFs) and network regions in the "Quiet-Sun" near the solar disc centre was studied. Observations were made by G-band filter in Solar Optical Telescope (SOT) onboard Hinode for intensity oscillations; Doppler velocity, magnetic field,

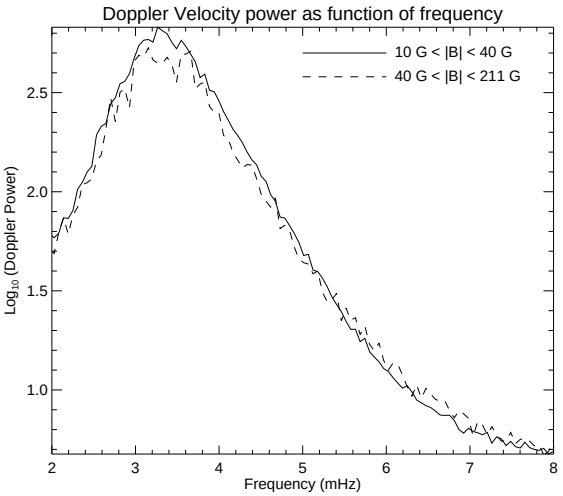

Figure 1.14: Log_{10} of the observed Doppler velocity power for two ranges of magnetic field strengths $10 < B < 40$ G (solid line) and $40 < B < 211$ G (dashed line) in a very quiet-sun. Note that the enhancement was seen in high-frequency waves (above 5.5 mHz) in strong field cases whereas the p-modes oscillatory power (below 5.2 mHz) was suppressed.

continuum intensity derived from Ni i photospheric absorption line at 6767.8Å using the Michelson Doppler Imager (MDI) onboard Solar and Heliospheric Observatory (SOHO) were used. The analysis showed that both the high resolution intensity observed in G-band and velocity oscillations were suppressed in the presence of magnetic field. While intensity oscillations were suppressed at all frequencies in high magnetic field regions compared to low magnetic field regions, velocity oscillations showed enhancement of power in the frequency band 5.5–7 mHz. It was found that there was a drop of 20–30% in the p-mode power of velocity oscillations within the SMFs when compared to the regions surrounding them. The findings indicated that the nature of interaction of acoustic waves with the "Quiet Sun" SMFs was similar to that of largescale magnetic fields in the active regions (Figure 1.14).

(Lakshmi Pradeep Chitta, R. Kariyappa, Rekha Jain & Stuart M. Jefferies*)*

Long-period intensity oscillations of the quiet solar atmosphere from TRACE 1600Å continuum observations

A six hour long time sequence of ultraviolet (uv) images obtained on May 24th, 2003 in 1600Å continuum under high spatial and temporal resolution from the Transition Region and Coronal Explorer (TRACE) were analysed. Fifteen isolated bright points, 15 network elements and 15 quiet background regions from these images were selected for detailed analysis. The cumulative intensity values and the light curves of these features for the total duration of observations were derived, and a power spectrum analysis was performed using the complete time-series data. It was found that the uv-bright points, the UV network and the UV background regions exhibit long-period intensity oscillations of periods 5.5 hours, 4.6 hours and 3.4 hours respectively, in addition to the more familiar small-scale intensity fluctuations, suggesting that these longer periods of oscillation might be related to solar atmospheric g-modes.

(R. Kariyappa & L. Dame)*

Propagating disturbances in polar plumes & interplumes

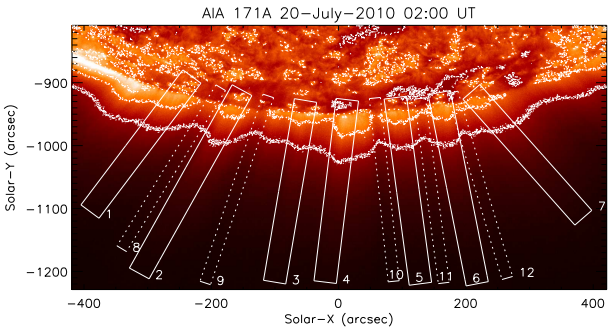

Figure 1.15: A snapshot of the south polar region depicting various plume and interplume regions traced. Intensity contours in white show the clear plume interplume distinction.

Quasi-periodic intensity variations were first reported in polar plumes using the white light channel in UVCS/SoHO. These variations are thought to be signatures of compressional waves. Observations from EIT/SoHO indicated that these disturbances were ubiquitously present in the polar regions. Later these disturbances were also observed in on-disk fan like coronal loops, using observations from TRACE. Modeling and theoretical studies combined with their observed properties imply that these are slow magneto-acoustic waves. Recently, it was argued that the quasi-periodic high speed upflows could also produce similar observational signatures and it was difficult to distinguish them from the magneto-acoustic waves, using the current available techniques. A

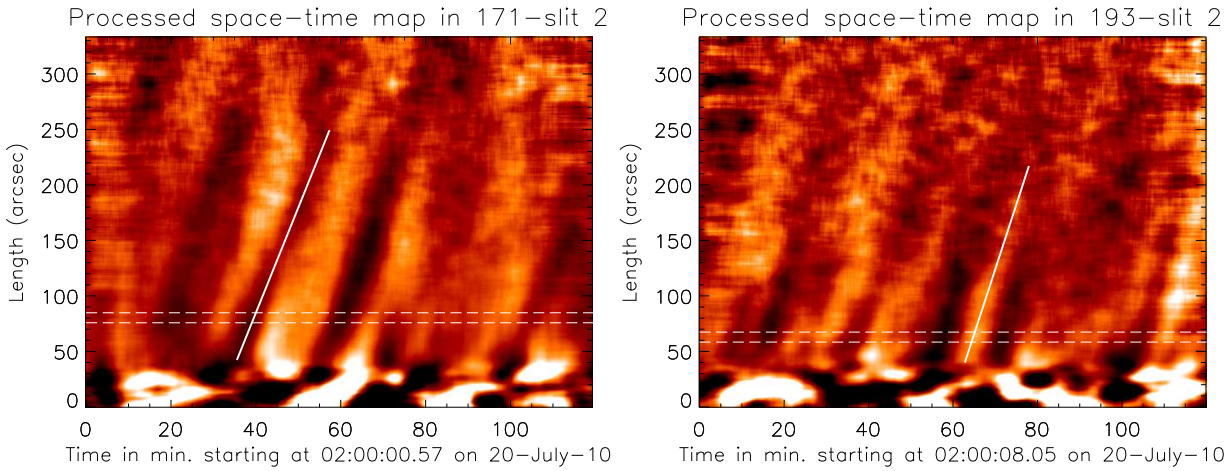

Figure 1.16: Processed space-time map for the region marked as slit 2 in Figure 1.15, in 171Å (left) and 193Å (right) channels of AIA/SDO.

clear understanding of the basic physical mechanism involved is essential since the significance of these disturbances in fast solar wind acceleration and/or coronal heating is determined by their nature. Also, whether the plumes or interplumes are the preferred channels for the acceleration of fast wind, is a topic of debate.

Several plumes and interplumes were analysed in three different EUV channels of AIA centered around 171Å, 193Å, and 211Å with their peak response temperatures at 0.8 MK, 1.25 MK, and 1.6 MK respectively (Figures 1.15 and 1.16).

Artificial slits were made along the structures, as shown in Figure 1.15, to extract space-time maps, which were then processed to enhance the fine variations, if any present. One such processed map was shown in Figure 1.16, in 171Å (left) and in 193Å (right) channels of AIA. The slanted solid lines were used to estimate the propagation speed and the rows between horizontal dashed lines were summed for wavelet analysis. Propagating quasi-periodic disturbances were observed ubiquitously, both in plume and interplume regions even after avoiding the contribution from jets. They were observed in the far off-limb upto ($\approx 250''$). They were also found to be unaltered by changes in the slit width within certain limits indicating involvement of coherent mechanism. The periodicities were in the range of 10 min to 30 min and the projected propagation speeds in the range 100 – 170 kms^{-1}. The average propagation speed was higher in 193Å channel, than in 171Å channel indicating the temperature dependence. The average propagation speed in the interplume regions was slightly higher than that of the plume regions. Although, the observed properties favour the interpretation of these disturbances as slow magneto-acoustic waves, simultaneous spectroscopy was needed to clearly understand their nature.

(S. Krishna Prasad, D. Banerjee, & G. R. Gupta)

Force-free models of magnetic fields and application to solar active regions

A general class of force-free fields are obtained when the energy is minimized with constraints on total mass, angular momentum, cross-helicity and relative helicity. Within the context of force-free configurations, there are numerous possibilities that could be obtained due to underlying geometry and symmetry of the problem in addition to the invariants involved. The goal here was to take the simplest geometric approach of a sphere. Self-similarity was shown to lead to two well known solutions, one which is linear and another non-linear. Several attempts were made to construct full three dimensional models from two dimensional three component data available from vector magnetograms. Since numerical models required good input fields for fast convergence, fits to the data using analytic solutions as a first attempt were explored. If the predictions of these computationally cheap fully three dimensional analytic models are comparable with other numerics or with observations, then one could take advantage of these analytic models to make more precise predictions of the physically relevant quantities such as relative helicity and free energy.

General solutions of the force-free equations un-

der the assumptions of axisymmetry and separability in radial and angular variables, in particular linear force-free fields and generalization of non-linear force-free fields in spherical geometry have been studied. These solutions have been applied to observed vector magnetograms of active regions obtained from the spectro-polarimeter on-board Hinode to calculate the free-energy and relative helicity for these configurations. In cases when a time-sequence of magnetograms was available before and after a flare event, the variation in energy and relative helicity for the active region as a function of time was derived.

(A. Prasad, A. Mangalam & B. Ravindra)

The coronal green line profiles

The coronal green line (Fe XIV 5303Å) profiles were obtained from Fabry-Perot interferometric observations of the solar corona during the total solar eclipse of 21st June, 2001 from Lusaka, Zambia. The instrumental width was about 0.2Å and the spectral resolution was about 26000. About 300 line profiles were obtained within a radial range of 1.0–1.5 $R_\odot$ and position angle coverage of about 240°. The line profiles were fitted with single Gaussian and their intensity, Doppler velocity, and line width had been obtained. Also obtained were the centroids of the line profiles which gave a measure of line asymmetry. The histograms of Doppler velocity showed excess blueshifts while the centroids revealed a pre-dominant blue wing in the line profiles. It had been found that the centroids and the Doppler velocities were highly correlated. This pointed to the presence of multiple components in the line profiles with an excess of blueshifted components. The (blue–red) wing intensity was obtained which clearly revealed the second component, majority of which were blueshifted ones. This confirms that the coronal green line profiles often contain multicomponents with excess blueshifts which also depend on the solar activity. The magnitude of the Doppler velocity of the secondary component was in the range 20–40 km/s and they showed an increase towards the poles. The possible explanations of the multicomponents could be the type II spicules which were recently found to have been important to the coronal heating or the nascent solar wind flow, but the cause of the blue asymmetry in the coronal lines above the limb remains unclear.

(K. P. Raju, T. Chandrasekhar & N. M. Ashok*)*

The EUV network studies

The properties of the EUV network in the solar atmosphere were examined using the SOHO/CDS data. The intensities, Doppler velocities and linewidths of the network and the cell region were compared in the coronal hole and the quiet Sun. Five strong emission lines, namely, OIII 599Å, OV 630Å, NeVI 562.8Å, HeII 304(2)Å, and MgIX 368Å were used in the study. It has been found that the intensities, Doppler velocities and linewidths were enhanced in the network region. The interrelations between intensity, Doppler velocity and width were also being examined which was expected to have some implications to the coronal heating.

(K. P. Raju & B. J. I. Bromage)*

Synoptic solar studies using Kodaikanal Ca K data

The Ca-K images of the Sun from Kodaikanal had a data span of about 100 years. This covers over 9 solar cycles and is therefore a good opportunity to study the synoptic solar activity. The Ca-K images are dominated by the chromospheric network and plages which are good indicators of activity. Further, the Ca-K line is a good proxy to the UV irradiance. This was particularly useful in the pre-satellite era where UV measurements were not available. The archival data are now available in the digitized form. In order to get useful information, these extensive data needed to be calibrated. Programmes have been developed for data reduction and analysis. In a preliminary study, some programmes have been developed to obtain the network and plage indices. Further analysis is underway.

(K. P. Raju & Suraj G. Gupta)*

Model for solar granules

A model for solar granules was developed by considering the equation of continuity, motion, state, energy along with radiative transfer equation in a plane parallel geometry. The above equations were solved simultaneously for the one-dimensional case in the Cartesian co-ordinate system. It was assumed that the energy loss was mainly due to radiative losses. The variations of physical variables were taken only along the direction where the gravity acted. The purpose of this model was to explain the sensitivity of radiative losses to the properties of the fluid

(like temperature, pressure, density and velocity of the fluid).

(B. S. Nagabhushana & M. Srinivasa Rao)

Solar cycle variations in the growth and decay of sunspot groups

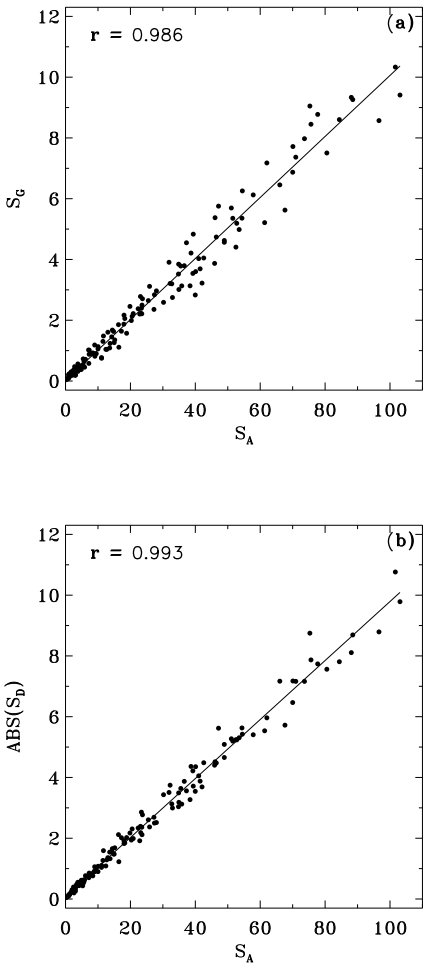

Figure 1.17: Plots of S_G and absolute S_D *versus* S_A (all the values were divided by 10^4). The solid lines represented the corresponding linear relationships with slopes 0.100 ± 0.001 (upper panel) and 0.097 ± 0.001 (lower panel). The corresponding correlation coefficients (r) were also shown.

It is known that the total solar irradiance (TSI) varied by about 0.1solar cycle. The TSI is well correlated to the solar activity. It is also known that sunspots and faculae acted in opposite to modulate TSI. That is, sunspots depress the solar energy output, whereas faculae enhance it. Earlier, from the analysis of the combined Greenwich (1874 – 1976) and Solar Optical Observatories Network (1977 – 2009) data on sunspot groups, it was found that there was no significant correlation either between the mean spot group growth rate and the sunspot number in a given time interval or between the mean spot group decay rate and the sunspot number. (The growth and decay rates of the spot groups were determined as follows: the daily rate of change of the area ($\frac{\Delta A}{\Delta t}$) of a spot group was computed using the differences between the epochs of its observation in consecutive days and between the corrected whole spot areas of the spot group at these epochs. Positive/negative values of $\frac{\Delta A}{\Delta t}$ represented the growth rate (G)/decay rate (D) of the spot group.) Recently, the analysis was extended and found that the total amounts of growth ($S_G = \Sigma G$) and decay ($S_G = \Sigma D$) of spot groups in a given time interval (example one-year) was well correlated to the amount of activity ($S_A = \Sigma A$) of the same interval (see Figure 1.17). Obviously, the patterns of variations in S_G and S_D during the period 1879 – 2008 closely matched with the patterns of the corresponding solar cycles, Nos. 12 – 23. Hence, it was suggested that the decay of spot groups may have enhanced the energy output, and therefore have a contribution for the existence of correlation (instead of anti-correlation) between TSI and sunspot activity.

(J. Javaraiah)

Does the Sun's surface equatorial rotation rate vary?

Studies on the solar cycle variations in the solar differential rotation were important for understanding the physical system which generated the solar activity and the solar cycle. The solar differential rotation was well studied, besides from the Doppler velocity measurements, using the data on different solar magnetic tracers (mainly the sunspots and the sunspot groups). The results derived from the sunspot and the spot group data showed variations in both the equatorial rotation rate and the latitude gradient of the rotation on several timescales, including the timescales close to the 11-year solar cycle. The $\approx$ 11-year period torsional oscillation (11-year variation in the latitude gradient of the rotation) detected from the Mt. Wilson Doppler velocity measurements were confirmed from the helioseismic studies. However, variations in the equatorial rotation rate determined from the Mt. Wilson Doppler measurements were doubted so far as an artifact of inconsistency in the data due to the frequent changes in the Mt. Wilson spectrograph instrumentation. Recently, the

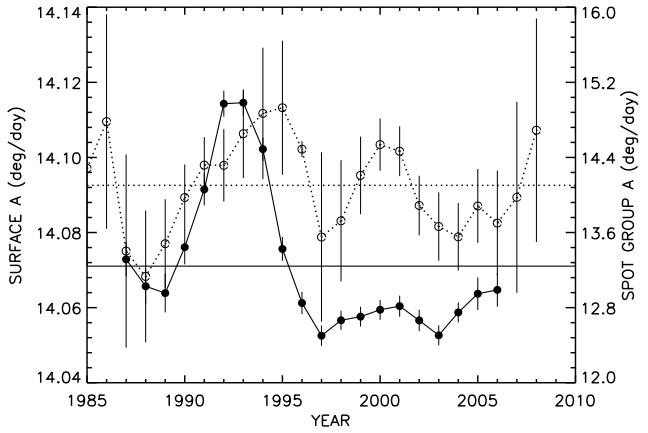

Figure 1.18: The filled circle–solid curve represents the 3-year smoothed A derived from annual mean values determined from the Mt. Wilson velocity data. The open circle – dotted curve represents the variation in A derived from the spot group data in 3-year moving time intervals successively shifted by one year, included with the abnormal ω values ($> 3^\circ$ day^{-1}). The solid and dotted horizontal lines are drawn at the mean values of A, 14.07° day^{-1} and 14.1° day^{-1}, determined from the Doppler velocity data and the spot group data, respectively.

Solar Optical Observatory sunspot group data during 1985 – 2009 and the Mt. Wilson Doppler velocity data during 1985 – 2007 were analysed and determined the variations in the annual mean equatorial rotation rates (the intercept term, A, in the equations of the traditional laws of the solar differential rotation) of the sunspot groups and the Sun's surface. The solar cycle variation in A determined from the Mt. Wilson Doppler velocity data was found to substantially differ with the corresponding variation in A determined from the sunspot group data that did not include the abnormal angular motions ($> 3^\circ$ day^{-1}) of the spot groups. On the other hand, the variation in A determined from the velocity data closely resembled the corresponding variation in A determined from the spot group data that included the abnormal angular motions (Figure 1.18). A reason for this could be the solar rotation rates determined from the spot group data with and without the contributions of the abnormal motions of the spot groups represented the rotation of the shallower layers and the relatively deeper layers of the Sun, respectively.These results strongly indicated that the solar cycle variation in the surface A determined from the Doppler measurements was a real property of the Sun's surface rotation.

(J. Javaraiah)

Smallscale chromospheric velocity structures

The chromospheric velocity structures observed simultaneously in Hydrogen alpha and Ca II 854.2 nm (CaIR) lines have been analysed. The data were a part of the full Stokes spectro-polarimetric observations and were obtained in the H-alpha and CaIR lines using the SPINOR instrument at the Dunn Solar Telescope. The velocity structures reported here are the upflows surrounded by the downflows. The magnitude of up- and down-flows range from 2 to 4 km/sec. Typical sizes of these structures are 5-6 arcsec with the lifetime of 7-15 min. Detailed analyses of velocities correspond to the bisectors at different line intensity levels suggesting that these structures are confined to the lower to middle chromosphere. Most of these structures were found above plage regions, implying that they are possible signatures of interaction between the plage magnetic fields and the over-lying canopy fields.

(K. Nagaraju, K. E. Rangarajan, K. Sankarasubramanian* & D. P. Choudhary*)*

Rotation rates of the coronal holes and their probable origin

As part of the ISRO funded project, two years of SOHO/EIT 195Å calibrated images are used for understanding latitudinal and day-to-day variations of rotation rates and, genesis of the Coronal Holes (CH). On the observed solar disc, CH are detected and weighted average of heliographic coordinates such as latitude (θ) and longitude from the central meridian are estimated. For different latitude zones, rotation rates Ω are computed. Following are the important findings. For all latitude zones, CH rotate rigidly yielding a rigid body rotation law of the following form: $\Omega = 13.721(\pm0.40) - 1.78(\pm3.15)\sin^2\theta\, deg/day$ or $\Omega = 441.34(\pm13.07) - 64.01(\pm117.5)\sin^2\theta\, nHz$. Irrespective of different latitude zones, it is found that there is almost a trend of constant rotation rate for the CH during their evolutionary history. During their initial appearance also, for all the latitude zones, CH rotate rigidly yielded a rigid body rotation law of the form $\Omega = 433.98(\pm6.84) + 1.40(\pm59.73)\sin^2\theta\, nHz$. These results suggest that all the CH have probably originated below base of the convection zone. As the average rotation rates of CH were $\sim$ 434 nHz during

their initial appearance, from the helioseismic inferences of rotation rate of the solar plasma, probable anchoring depth of CH used in the present analysis is estimated to be ~ 0.6 $R_\odot$ (where $R_\odot$ is radius of the sun).

(K. M. Hiremath, Manjunath Hegde & J. B. Gurman)*

Dynamical and thermal properties of the coronal holes

Solar cycle and activity phenomena such as coronal holes (CH) strongly influence the Earth's environment and climate (Hiremath, Sun and Geosphere, 4, 16, 2009). As part of an ISRO funded project, from the two years of SOHO/EIT 195Å calibrated images, CH are detected and, day to day and latitudinal variations of area and average photon fluxes are measured. Life span of a typical CH is estimated. In addition, energy emitted by the CH with their temperature and strength of magnetic field structures are estimated. Following are the important findings. Variation of area (A), photon flux (F), energy (E) and temperature (T) of CH are independent of latitudes. Typical values of these physical parameters are: $A = 2.6(\pm 0.09) \times 10^{22}$ cm^2, $F = 3.8(\pm 0.7) \times 10^{12}$ $photons\ cm^{-2} sec^{-1}$, $E = 2.02(\pm 1.4) \times 10^{17}$ $ergs\ sec^{-1}$ and, $T = 7.7(\pm 0.8) \times 10^5$ K. Life span of CH is estimated to be ~ 22 days. Strength of the magnetic field structure of CH is estimated to be $\sim 4 \pm 2$ gauss. If CH flux tubes are anchored in the convection zone, one would expect CH to rotate differentially and hence, thermal wind balance with the isorotation contours implied the temperature difference between the equator and the pole. Contrary to this fact, thermal structure of CH from the present study is independent of latitude leading to a strong conclusion that CH must rotate rigidly.

(K. M. Hiremath, Manjunath Hegde & J. B. Gurman)*

Probing of solar core rotation

Chandrasekhar's modified MHD equations are used for probing the solar core rotation. With reasonable assumptions of axisymmetry and fluid incompressibility along with simplifying approximations (such as magnitudes of meridional velocity, poloidal and toroidal parts of magnetic field structures were negligible), two simultaneous hydrodynamic equations ($\frac{\partial \Omega}{\partial t} - \nu \Delta_5 \Omega = 0$ and $\frac{\partial \Omega^2}{\partial z} = 0$, where Ω was angular velocity, ν is viscosity and Δ_5 is a five dimensional Laplacian operator) were obtained and, it was possible to get an analytical solution for the core angular velocity. Proper boundary conditions were then applied to generate profiles similar to those inferred by helioseismology near the convective envelope. It was found that in order to satisfy rotational boundary conditions near the base of the convective zone, the magnitude of solar core rotation was obtained to be $\sim 2.8 \times 10^{-6}$ rad/sec and, the rotational diffusion timescale was found to be of $\sim 10^{14}$ years.

(K. M. Hiremath & K. Vorren)*

Mass, dynamics and energetics of the solar eruptive limb prominences

Solar limb prominences are cool and dense plasma structures suspended in the sun's atmospheres. When viewed on the surface of the sun, these structures are called as filaments. Existence of such a cool and dense plasma structure suspended in the hot and rarefied corona is a mystery. As 70% of the eruptive prominences are associated with CMEs and are probably the likely candidates for triggering of catastrophic events, especially the quakes in the nearby planets, accurate determination of their dynamics and energetics of the eruptive prominences is necessary. In the present study, hourly STEREO/SECCHI EUVI images at 304Å were used for the computation of different physical parameters such as velocity, mass, volume, momentum and energy during their eruption that were transferred by the gigantic solar prominences to the interplanetary environment. Hourly evolutionary history of three eruptive limb prominences (29 September 2008, 16 June 2008, and 14 April 2010) were considered and aforementioned physical parameters were derived. Following are the preliminary results: (i) average mass of these solar prominences is estimated to be $\sim 10^{11} - 10^{12}$ kg,(ii) average momentum is estimated to be $\sim 10^{14}$-10^{15} kgM/sec and, (iii) estimated energy transferred to the interplanetary environment is of the $\sim 10^{17} - 10^{19}$ joules. Estimated masses of the prominence are almost similar to the masses estimated by the previous studies from the SOHO images. It is interesting to note that the estimated energy is almost similar to the energy released during the powerful earthquake of magnitude > 6 on the Richter scale.

(K. M. Hiremath, S. B. Gudennavar, Lijo Thomas* & Sr. Mary Gracy*)*

Clues for absence of super Earths: evidence of accretion of 8 Jupiter mass

The study on the absence of super earths in the vicinity of the sun is continued. Owing to peculiar physical properties (such as high mass, metal rich, dynamically unexpected rotational shear layer near the surface, etc.,) of the sun among all the stars in its immediate neighborhood in the Galaxy, in the previous study, it was argued that for the absence of super earths in the vicinity of the sun, 8 Jupiter mass that must have been distributed in formation of the terrestrial planets (total mass of all the terrestrial planets, moon and the asteroid belt is $\sim 0.006 M_J$, where M_J is mass of the Jupiter), it might have accreted on to the sun. If such an accretion occurred during the early epoch of the solar system formation, the accreted layer may not have rotated greater than the Keplerian angular velocity and rotating layer might have been formed with the fast rotating nascent sun. In fact such a rotational shear layer near the surface has been discovered from the helioseismic inferences and from the occurrence of the flares due to abnormal rotation rates (Hiremath and Suryanarayana, A & A, 411, L497, 2003) inferred from the Kodaikanal Observatory data. If such a rotational shear layer exists, it is also interesting to check whether remnant of the Keplerian angular velocity ($\Omega(r)\ \alpha\ r^{-3/2}$, where $\Omega(r)$ is the radial angular velocity and r is the radial coordinate) profile near the surface exists. In order to test this reasoning, sun's shear rotational profile inferred from the helioseismology in the radial ($0.915 R_\odot$ to $1 R_\odot$) direction and integrated over the latitude zones (15^o north-15^o south) is considered and subjected to a polynomial ($\Omega(x) = \sum_{i=0}^{\infty} \frac{A_i}{x^i}$, where $x = r/R_\odot$ and A_i are constant coefficients to be determined from the least square fit) fit. According to the expectation, except third degree coefficient, the second degree ($x^{-2} \sim x^{-1.5}$-a Keplerian angular velocity) polynomial has a dominant coefficient that reinforces the conjecture that 8 Jupiter mass might have accreted on to the sun and might have distributed in the near surface rotational shear layer. However, during the accretion period, magneto-rotational instabilities might have modified the initial Keplerian radial angular velocity profile that suggests non-zero coefficients of other degrees of the polynomial fit. Hence, unexpected rotational shear layer near the surface must be remnant of the Keplerian rotational profile that might have been obtained during the early history of the solar system formation.

(K. M. Hiremath)

Radio observations of weak energy releases in the solar corona

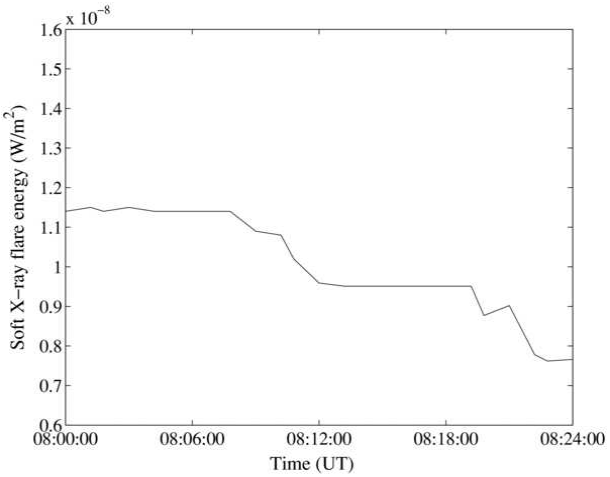

Figure 1.19: Soft X-ray (0.5-4 A) flare energy observed from the whole Sun during the interval 08:00-08:24 UT on May 8, 2009 with the X-ray sensor onboard GOES 10. The integration time is 1m.

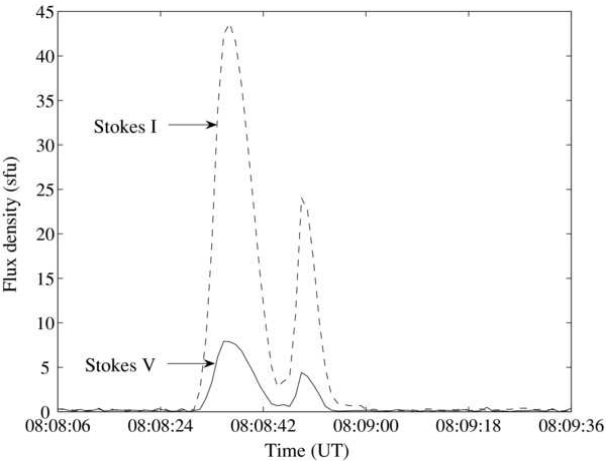

Figure 1.20: 77 MHz time profile of the Stokes I & V emission observed from the Sun around the same time as the X-ray obervations in the previous figure. The integration time is 1s.

Solar flares occur over a wide range of energies: from 10^{29} erg for subflares to 10^{32} erg for the largest flares. The frequency of flares continue to increase as one looks at weaker and weaker energy releases. High-sensitivity ballon-borne experiments have detected weak hard X-ray spikes/bursts (called "microflares" since the energy involved was 10^{26}-10^{28} erg) which are attributed to such energy releases. Microflares

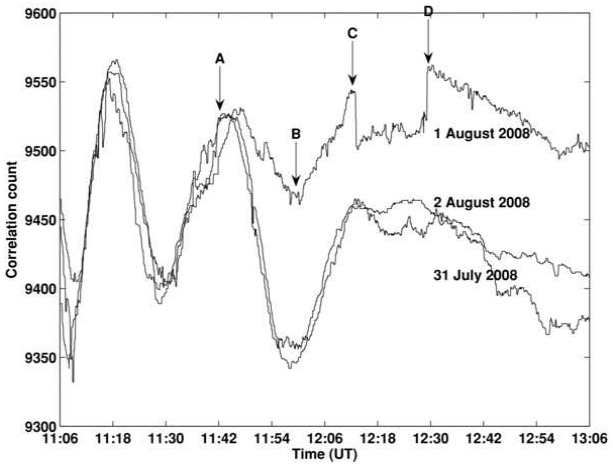

Figure 1.21: Observations of the solar corona at 170 MHz on 31 July, 2008, and August 1 & 2, 2008 with a two-element interferometer system at the Gauribidanur observatory. The dip during the time interval 12:12-12:29 UT in the observations on August 1, 2008 corresponded to the occultation of a discrete radio source in the solar corona by the Moon. The variation in the mean level of the fringes was due to the absence of phase switching in the receiver system.

are of interest because of their possible bearing on the problems of coronal heating and solar flares. These events are impulsive and non-thermal. In addition to the afore-mentioned X-ray events, magnetic energy is released in several different forms that are not necessarily related to the traditional definition of flares. The characteristics of radio frequency signatures of such events have been similar to the commonly observed type III radio bursts from the solar corona, which were due to plasma emission. The weak radio bursts observed at radio frequencies have been termed as microbursts since their peak brightness temperature (Tb) is 10^6 K, unlike the regular type III bursts whose average Tb 10^{10} K at a typical frequency of 80 MHz. Numerical simulations indicate that type III bursts with different Tb values can be explained by varying the coronal and heating conditions in the region where they occur. For weak heating events or events with high coronal electron temperature, the simulations give rise to bursts with characteristics that quantitatively agree with microbursts. In this scenario, here, the positional, spectral, and polarization information on a class of weak type III bursts with peak Tb intermediate between that of the microbursts and regular type III bursts mentioned above are investigated. The bursts were not accompanied by any activity in either Hα or X-rays or microwaves. The estimated total energy in the non-thermal electrons that caused the burst in the present case was found to be about two orders of magnitude lower than the corresponding energy in the weakest (10^{26} erg) hard X-ray microflares mentioned above. (Figure 1.19 and Figure 1.20).

(R. Ramesh, C. Kathiravan, Indrajit V.Barve, G. K. Beeharry & G. N. Rajasekara)

Radio observations of the solar corona during an eclipse

The solar corona can be routinely imaged from the ground at low radio frequencies (30-300 MHz) since the observed emission originates primarily there. The main limitation of the observations is the angular resolution. During a solar eclipse, the angular extent of the radio source(s) located along the trajectory of the Moon could be identified with high angular resolution using the diffraction effects provided by the Moon's sharp limb similar to the lunar occultation technique. The angular dimension of such regions could be estimated to an accuracy of 10 arcsec in the above frequency range because of the diffraction effects at the Moon's limb. Radio observations of the solar corona at 170 MHz have been carried out during the eclipse of August 1, 2008 from the Gauribidanur observatory located about 100 km north of Bangalore in India. The results indicate the presence of a discrete radio source of very small angular dimension (15 arcsec) in the corona from where the observed radiation originated. This is about a factor of two lower than the sizes of the smallest discrete sources in the solar corona reported till date. Similar observations in two dimensions might be useful to infer the limiting sizes of the discrete radio wave emitting solar sources at low frequencies (Figure 1.21).

(C. Kathiravan, R. Ramesh, Indrajit V. Barve & M. Rajalingam)

1.2 Stellar and Galactic Astrophysics

Variable circumstellar activity of the pre-main sequence star V351 Orionis

Temporal variability in the accretion/outflow processes in young pre-main sequence stars and their circumstellar environment could cause changes in the strength and profiles of the emission and absorption lines in the spectra of these objects. The patterns and timescales of line profile variability have been investigated in order to explore the dynamical circumstellar environment of the pre-main sequence Herbig Ae star V351 Ori. High-resolution (R 28000) spectra of V351 Ori were obtained on 45 epochs covering timescales of hours, days, and months. The Hα line profiles were studied in detail and the Hβ, NaD1 and NaD2 line profiles were also examined to explore the nature of the spectroscopic variability.

The Hα line profiles showed strong variations over all timescales. The shape of the profiles changed over timescales of a day. Single as well as simultaneous event(s) of blue-shifted and red-shifted transient absorption components, i.e. signatures of outflow and infall, were also observed in the Hα line profiles. The shortest period of variation in the transient absorption components was $\leq$1 hour. All transient absorption events were found to decelerate with a rate of a few to fractions of ms^{-2}. The depth and width of the transient absorption components have also been changing with time. The presence of elongated red-shifted components at some epochs supports the episodic nature of accretion.

The Hα non-photospheric profiles of the star most probably originated in the disk wind. Episodic accretion of gaseous material at a slow rate and outflow of clumpy gaseous material have still been occurring in V351 Ori at an age of 6.5 Myr. Dynamic magnetospheric accretion and disc wind emerge as the most satisfactory model for interpreting the observed line profile variations of V351 Ori.

(R. Choudhury, H. C. Bhatt & G. Pandey)

CCD time-series photometry of the globular cluster NGC 6981: variable star census and physical parameter estimates

The results from 10 nights of observations of the globular cluster NGC 6981 (M72) in the V, R and I Johnson wavebands have been presented here. The technique of difference image analysis has been employed to perform precision differential photometry on the time-series images, which enabled to carry out a census of the under-studied variable star population of the cluster. Twenty suspected variables in the literature have actually been non-variables, and the variable nature of another 29 variables while refining their ephemeris have been confirmed. Eleven new RR Lyrae variables and three new SX Phe variables have been detected, bringing the total confirmed variable star count in NGC 6981 to 43. Fourier decomposition of the light curves have been performed for a subset of RR Lyrae stars and the Fourier parameters have been used to estimate the fundamental physical parameters of the stars using relations available in the literature. Mean values of these physical parameters have made it possible to estimate the physical parameters of the parent cluster. A metallicity of [Fe/H]ZW of $-$ 1.48 $\pm$ 0.03 on the Zinn & West scale (or [Fe/H]UVES of $-$ 1.38 $\pm$ 0.03 on the new Carretta et al. scale for NGC 6981, and distances of $\sim$ 16.73 $\pm$ 0.36 and $\sim$ 16.68 $\pm$ 0.36 kpc from analysis of the RR0 and RR1 stars separately have been derived. The Oosterhoff type I classification for the cluster has been confirmed, and shows that the colour-magnitude data obtained here have been consistent with the age of $\sim$ 12.75 $\pm$ 0.75 Gyr in the literature (Figure 1.22).

(D. M. Bramich, R. Figuera Jaimes*, S. Giridhar, A. Arellano Ferro*)*

Aspects of triggered star-formation

This problem envisages two principle paradigms; formation of stars via - (a) dynamic interaction between interstellar shocks and self-gravity of large molecular clouds, and (b) exposure of molecular clouds to a flux of ionising radiation. The former realisation, also called as the collect and collapse model operates in two phases. Dense molecular gas is collected in the first phase, and stars form in pockets of dense gas so assembled. Shock-waves originating from an energetic phenomenon such as a supernova, or an expanding bubble of ionising radiation are believed to lead to this possibility. Dense shells of molecular gas swept up by strong interstellar shock-waves have been confined by ram-pressure on either face, and likely, fragment into large clumps, typically having a mass in excess of a few thousand Solar masses. This hypothesis was examined in a recent work and generated a mass spectrum for clumps condensing out of such shells by performing several thousand Monte-Carlo realisations of the problem. The resulting mass-spectrum, that has a slope similar to that

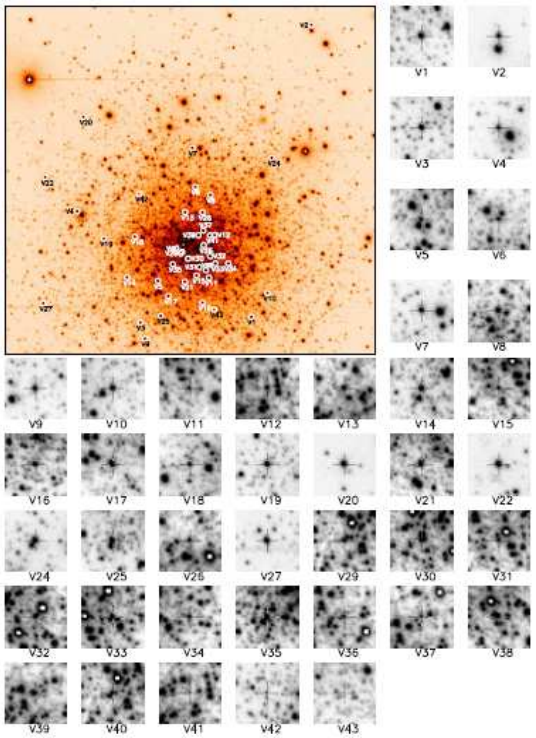

Figure 1.22: The figure contains finding charts constructed from the V reference image; north is up and east is to the right. The size of the cluster image is $5.31'$ $\times$ $4.93'$, and the image stamps are of size $23.7\,'' \times 23.7''$. Each confirmed variable lies at the centre of its corresponding image stamp and is marked by a cross-hair.

for the distribution of large molecular clouds, has been shown in Figure 1.23.

(*Sumedh Anathpindika*)

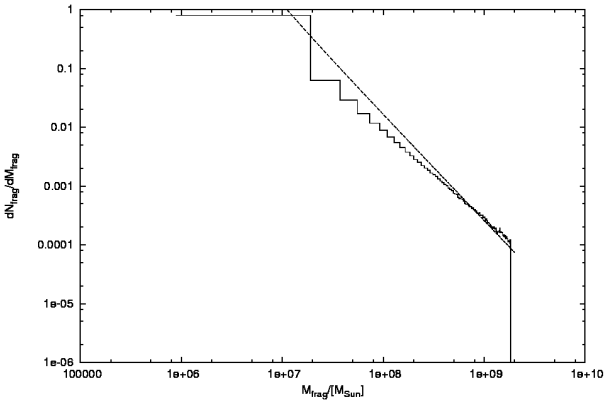

Figure 1.23: Clump mass spectrum for fragments condensing out of an SNR. Formation of massive clumps, though not ruled out, appears to be less probable.

Discovery of a Hydrogen-deficient carbon star from HCT

Hydrogen-deficient carbon (HdC) stars are a rare class of objects; only five Galactic HdC stars and about fifty one HdC stars of RCB type are known in our Galaxy. While HdC stars have been spectroscopically similar to the RCB type stars, they are distinct from RCBs, as they do not show the deep minima and infrared excesses that are characteristics of RCB stars. The small size of the group of HdC stars has been a major constrain for understanding their formation mechanism(s) and evolutionary properties. Using medium resolution spectroscopic data from Himalayan Chandra Telescope (HCT), HE 1015−2050 has been identified to be a hydrogen-deficient carbon star. The present discovery adds a new member to this rare group of objects (Figure 1.24 and Figure 1.25).

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

(A. Goswami, D. Karinkuzhi & N. S. Shantikumar)

Carbon in the inner and outer halo of the Galaxy

Building upon earlier results which showed that the Galaxy halo could be divided into an inner and outer halo, based on the kinematics and metallicities, it was found that the halo is chemically different and that the outer halo stars are more carbon enriched than the inner halo. The enrichment of carbon in the early Galaxy has had possible implications, either the two halos are made up of different populations also the change in the IMF in early Galaxy and possibly a Cosmic microwave Background based IMF.

(Carollo et al. & T. Sivarani)*

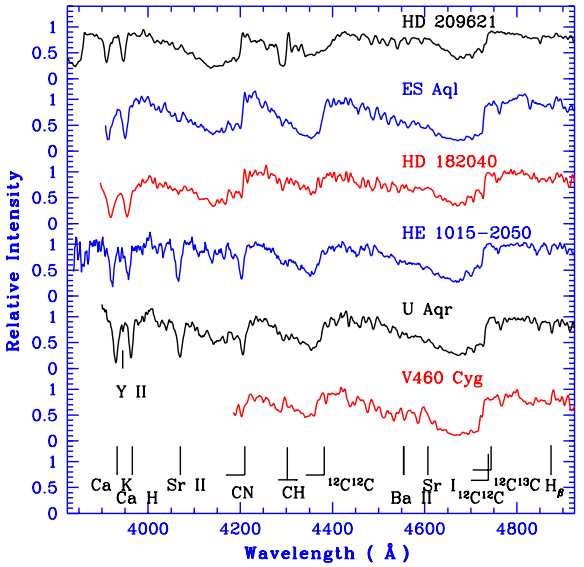

Figure 1.24: A comparison between the spectrum of HE 1015−−2050 with the spectra of V460 Cyg (a C-N star), U Aqr, ES Aql (cool HdC stars of RCB type), HD 182040 (a non-variable HdC star), and HD 209621 (a CH star) in the wavelength region 3850–4950ÅThe spectrum of HE 1015−2050 compares closest to the spectrum of U Aqr. Important features have been marked on the spectra

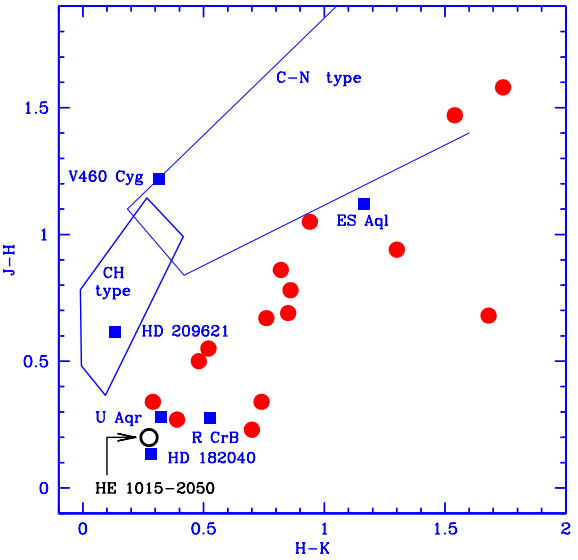

Figure 1.25: The location of HE 1015-2050 (open circle) in the vicinity of U Aqr (and other HdC stars) in the J-H, H-K plane supports its identification with the group same as that of U Aqr

Oxygen abundance in carbon enhanced metal poor (CEMP) star

Measurement of the oxygen abundance is quite challenging as it needs high resolution and high S/N spectra. A pilot survey was started with the SOAR-4m OSIRIS spectrograph, which proposed a unique way to derive oxygen abundances in CEMP stars, based on the NIR band low resolution spectra. It was found that majority of the CEMP stars showed evidences of AGB binary mass transfer. Some of the highly oxygen enhanced stars could be due to massive star wind or hyper novae pollution.

(C. R. Kennedy et al. & T. Sivarani)*

Alpha abundances for SDSS spectra and validation

Alpha abundances were derived for all the stars in the SDSS DR8 database between a temperature range of 4500 – 7000. Taking the full temperature range into consideration, preliminary tests indicated that a metallicity limit as low as [Fe/H] -3.0 may also apply to cooler stars. As a further validation of this approach, weighted averages of [α/Fe] obtained for SEGUE spectra of likely member stars of Galactic globular clusters (M 15, M 13, and M 71) and open clusters (NGC 2420, M67, and NGC 6791) exhibited good agreement with the values of [α/Fe] from previous studies. The results of the comparison with NGC 6791 implied that the metallicity range for the method may extend to +0.5.

(Y. S. Lee et al., J. P. Smolinski* et al. & T. Sivarani)*

The Multi-object APO (Apache Point Observatory) Radial Velocity Survey (MARVELS)

As a part of the MARVELS team, a new short-period brown dwarf (BD) candidate around the star TYC 1240-00945-1 has been discovered. MARVELS used the technique of dispersed fixed-delay interferometery to simultaneously obtain radial velocity (RV) measurements for 60 objects per field using a single, custom-built instrument that wass fiber fed from the SDSS 2.5m telescope. From the 20 RV measurements spread over a 370 day time baseline, a Keplerian orbital fit with semi-amplitude K = 2.533 ± 0.025 km s^{-1} was derived, period P = 5.8953 ± 0.0004 days, and eccentricity consistent with circular. Indepen-

dent follow-up RV data confirmed the orbit. Adopting a mass of 1.37 ± 0.11 $M_{\odot}$ for the slightly evolved F9 host star, it was inferred that the companion had a minimum mass of 28.0 ± 1.5 M Jup, a semi-major axis 0.071 ± 0.002 AU assuming an edge-on orbit, and was probably tidally synchronized. No evidence was found for coherent intrinsic variability of the host star at the period of the companion at levels greater than a few milli-magnitudes. The companion had an a priori transit probability of 14%. Although no evidence was found for transits, they cannot be definitively ruled out for companion radii l ∼ 1 R Jup.

(Lee et al. & T. Sivarani)*

Origin of Li in K giants

A low-resolution spectroscopic study of 2000 low-mass (M < = 3 $M_{\odot}$) giants spanning the luminosity range from below to above the luminosity of the clump has been conducted to search for Li-rich K giants. The entire survey was conducted using 2.3m VBT, 2m HCT and 1m telescope at VBO. Fifteen new Li-rich giants including four super Li-rich K giants (log epsilon(Li) > = 3.2) have been discovered. This was a major survey in which such a large number of Li-rich K giants were found, increasing the total number of Li-rich K giants by a factor of 2. A significant finding is that there is a concentration of Li-rich K giants at the luminosity of the clump or red horizontal branch. This new finding was partly a consequence of the fact that the low-resolution survey was the first large survey to include giants well below and above the red giant branch (RGB) bump and clump locations in the H-R diagram. The origin of the lithium enrichment may be plausibly attributed to the conversion of 3He via 7Be to 7Li by the Cameron-Fowler mechanism but the location for the onset of the conversion has been uncertain. Two possible opportunities to effect this conversion are the bump in the first ascent of the RGB and the He-core flash at the tip of the RGB. The finite luminosity spread of the Li-rich giants serve to reject the idea that Li enhancement is, in general, a consequence of a giant swallowing a large planet.

(Y. B. Kumar, Bacham E. Reddy & David L. Lambert)*

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

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

(A. Goswami, S. S. Kartha & A. K. Sen)*

Lithium abundances in the α Persei cluster

It is hard to interpret the Li abundance patterns of field stars because they span a range of age and chemical composition at any given temperature. Open clusters tell us so much more because each represents a sample of stars of roughly the same age and chemical composition. A study of Li in the α Persei cluster was undertaken based on data of 81 stars observed at a very high resolution with the echelle spectrographs at KPNO and McDonald observatories. There have been several studies in the past to explore in clusters a likely connection between Li abundance, chromospheric activity and rotation. With a larger sample, the question of whether the scatter in Li abundance at a given temperature seen in young clusters at the cool end is real or due to atmospheric effects has been re-examined. There is marginal evidence that the stars of high *v sin i* follow a different abundance vs. temperature trend to the slow rotators. Because of the KI λ7699 line (a good chromospheric diagnostic) observations have been available only in a limited sample of the programme stars, there was no conclusive evidence to any link between Li abundance and chromospheric activity. Questions were also addressed about when exactly there is onset of depletion in a cluster and how the star-to-star spread in Li

abundance developed at low masses. For stars cooler than 5500 K, Li declines steeply with decreasing temperature and there develops a star-to-star scatter in the Li abundance. The Li abundances for α Per fit the pattern provided by observations of clusters both younger and older than it. The star-to-star spread appears to develop after about 20 Myr. The scatter in α Per resembles the well-documented scatter seen in the 70 Myr old Pleiades cluster and is far less pronounced in the 30 Myr clusters. The spread survives up to 250 Myr or so as seen in M 34.

(Sushma V. Mallik, Suchitra C. Balachandran & David L. Lambert*)*

Recurrent Novae: U Scorpii

The recurrent novae U Scorpii was discovered in outburst on 2010 29 January. This tenth outburst was predicted by B. Schaefer based on a detailed study of its light curve over several decades. The outburst was extensively monitored spectroscopically using the HCT, at almost daily intervals during the early phases. Spectroscopic and polarimetric observations were also made with the IGO 2m telescope. Low frequency radio observations were also obtained with the GMRT. Analysis of the spectra indicate ejection of matter at extremely high velocities (10000 km/s). The line profiles are boxy and triple peaked, with a broad central component flanked by narrow components. Such boxy, triple peaked profiles have been found to be generally associated with He/N and hybrid novae, and attributed to an expanding bipolar and equatorial ring like shell structure. The optical light curves indicated the onset of the plateau phase by day 9. The onset of the supersoft X-ray phase, coincident with the plateau phase, is also coincident with the emergence of the He II lines that gain in strength during the plateau phase. During this phase, the Balmer lines were dominated by the central component, although the wings continued to be broad. The width of the central component narrowed with time, and decreased to ~ 600 km s^{-1} during the mid-plateau period. The plateau/SSS phase that lasted during days $\sim 9 - -41$ was dominated by the presence of the narrow emission lines of He II and the narrow Balmer lines. The end of the plateau and the SSS phase was marked by the dominance of the broad [O III] lines, as well as the re-appearance of the high velocity components in the Balmer lines. The emission lines show a highly structured profile. He II 4686Å was still present with a narrow profile.

While the spectral evolution is very fast and broadly similar to the previous outbursts, several rapid variations have been detected. Flares with a duration of $\sim$ 1 hr, and an amplitude of $\sim 0.1 -$ 0.5mag were reported during the early decline phases. These were first noted by Worters et al.(2010) IAUC 9114,1. The first such flare was recorded on February 3.86, day +6, and continued until day +13. Interestingly, the spectrum of February 4.016 obtained with the HCT showed a sharp absorption component at -500 km s^{-1} in the He I lines, and in the hydrogen, N I and Ca II lines beyond 8000Å. This velocity was very similar to the width of the narrow emission lines seen during the SSS/plateau phase.

Linear polarization observations made with the IUCAA IGO Telescope indicate an intrinsic polarization. The observed polarization, which was almost interstellar at $p_V = 0.69$ on day ~ 5.8, was found to have increased to $p_V = 1.39$ on day ~ 6.8. Similar levels of polarization were detected on the two other epochs of measurements on days 26.8 and 27.8, although marginally lower on day 27.8. It appears that U Sco exhibited intrinsic polarization during the plateau phase.

The nova was not detected in the radio.

(G. C. Anupama, U. S. Kamath, A. N. Ramaprakash, N. G. Kantharia*, M. Hegde, V. Mohan*, M. Kulkarni*, M. F. Bode*, S. P. S. Eyres*, A. Evans* & T. J. O'Brien*)*

Supernovae: SN 2009jf

The type Ib supernova SN 2009jf was monitored extensively using the 2m HCT, during the period ~ -15 to $+250$ days with respect to the B maximum. The light curves are broad, with an extremely slow decline. The early post-maximum decline rate in the V band is similar to SN 2008D, however, the late phase decline rate is slower than other studied type Ib supernovae. With an absolute magnitude of $M_V = -17.96 \pm 0.19$ magnitude at peak, SN 2009jf is a normally bright supernova. The peak bolometric luminosity and the energy deposition rate via ^{56}Ni $\rightarrow$ ^{56}Co chain indicate that $\sim 0.17^{+0.03}_{-0.03}$ M$_\odot$ of ^{56}Ni was ejected during the explosion. He I 5876Å line is clearly identified in the first spectrum of day ~ -15, at a velocity of ~ 16000 km sec^{-1}. The [O I] 6300-6364Å line seen in the nebular spectrum has a multi-peaked and asymmetric emission profile, with the blue peak being stronger. The estimated flux in this line implies $\gtrsim 1.3$ M$_\odot$ oxygen was ejected. The slow evolution of the light curves of SN 2009jf indicates the presence of a massive ejecta. The high

expansion velocity in the early phase and broader emission lines during the nebular phase suggest it to be an explosion with a large kinetic energy. A simple qualitative estimate leads to the ejecta mass of $M_{\rm ej} = 4-9$ M$_\odot$, and kinetic energy $E_{\rm K} = 3-8\times10^{51}$ erg. The ejected mass estimate is indicative of an initial main-sequence mass of $\gtrsim 20-25$ M$_\odot$.

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

Studies of type II SNe

Multiwaveband observations of type II supernovae are being carried out, monitoring their evolution from outburst to nebular phase, in order to (a) study the early time evolution, just after the shock break out, (b) study and constrain the plateau luminosity vs. expansion velocity relation for IIP-SNe at known distances, and (c) to study the nature of shock interaction with the CSM in the case of SNe-IIn. To date, we have studied the Sne-IIP SN2010hq and SNe-IIn SN2010jl, using data from Swift (UV+X-ray), Chandra(X-ray), HCT+Aries (optical) and GMRT/EVLA (radio), whenever available, to explain the origins of prompt emission in high energy bands from these SNe, as well to constrain hydrodynamical models of late stage evolutionary models of massive stars ($M > 8.5\ M_\odot$), as well as models on shock generation and propagation through their outer layers.

(F. Sutaria, A. Ray, S. Chakrabarti*, N. Yadav*, B. Kumar*, R. Roy*, S. Bose*)*

Role of rotation on coherent radio emission from pulsars

The morphology of radio profiles of pulsars are believed to be strongly influenced by the rotation effects such as aberration and retardation (A/R). A relativistic pulsar emission model was developed by taking into account the detailed geometry of the emission region and aberration. By computing the velocity and acceleration of the relativistic plasma, the electric field of radiation was estimated, and the spectral distribution (Stokes parameters) was obtained by taking Fourier transform.

Using the parameters magnetic axis inclination angle $\alpha = 10°$, sight line impact parameter $\sigma = 2°$, $\phi_m = 0°$, emission altitude $r_n = r/r_{LC} = 0.02$, pulsar period $P = 1$ s, $\gamma = 400$, and observational frequency $\nu = 600$ MHz, were simulated to obtain the parameters: I, L, and V, within the beaming region. Their contour plots have been given in magnetic coordinates (θ, ϕ)-plane in Figure 1.26. The parameters I, L, and V in both non-rotating and rotating cases were normalized with the corresponding maximum value of I. Due to aberration, contour patterns in the rotating case get rotated in the (θ, ϕ) plane relative to the non-rotating case. Hence an asymmetry in the strength of the emission occurs within the beaming region bounded by the ranges of θ and ϕ allowed by the geometry. This rotation of pattern is responsible for the wide diversity of circular polarization and position angle swing.

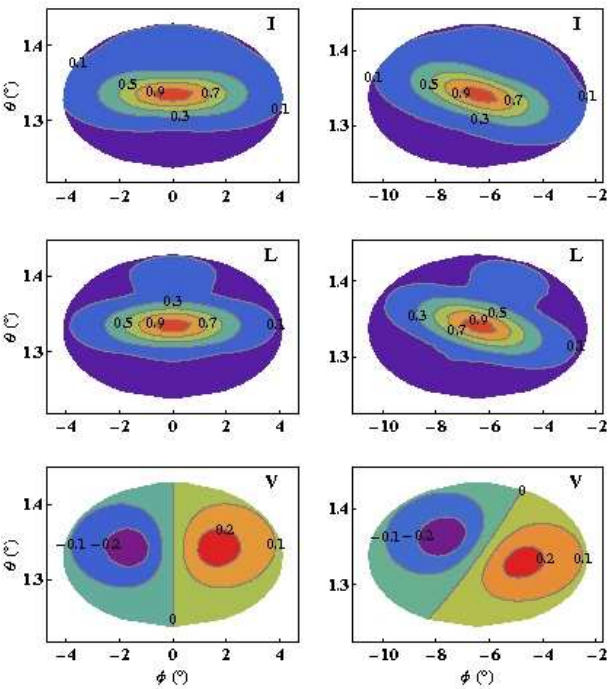

Figure 1.26: The simulation results showing the spectral emission from the beaming region in the non-rotating (left column panels) and the rotating (right column panels) cases of pulsar.

In general, pulsar average radio profiles consist of many components: central core emission surrounded by concentric conal emissions. Hence the emission region could be modeled by assuming Gaussian sources distributed within the emission region:

$$f(\theta,\phi) = f_0 \exp[-(\theta-\theta_P)^2/\sigma_\theta^2 - (\phi-\phi_P)^2/\sigma_\phi^2],$$

where θ_P and ϕ_P are the peak locations and f_0 is the amplitude. The parameters $\sigma_\theta = w_\theta/(2\sqrt{ln2})$ and $\sigma_\phi = w_\phi/(2\sqrt{ln2})$, where w_θ and w_ϕ are the full width at half-maxima (FWHM).

By considering a Gaussian modulation having a

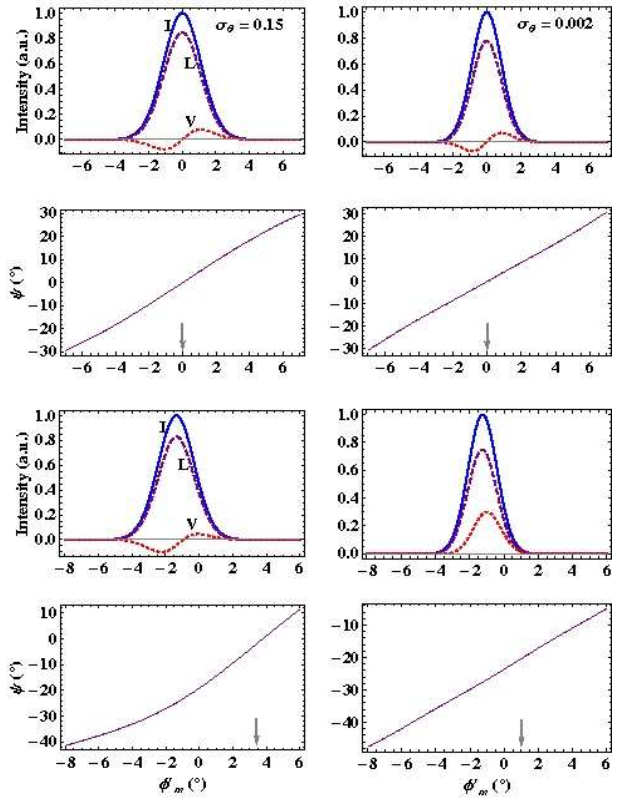

Figure 1.27: Simulated pulse profiles: The panels in the top two rows are for non-rotating case, and bottom two for the rotating. Chosen $f_0 = 1$, $\theta_P = 1.2°$, $\phi_P = 0°$, and $\sigma_\phi = 0.15$. In each panel I (solid blue curves), L (dashed purple curves), and V (dotted red curves) are normalized with the respective peak intensity. The continuous pink curve present the polarization angle (ψ) swing. Arrows mark the phase of intensity peak and the inflection point of ψ.

peak at $(\theta_P, \phi_P) = (1.2°, 0°)$ and using the same parameters used for Figure 1.26, simulating the polarization profiles are shown in Figure 1.27. To see the combined effect of aberration and modulation, two cases of modulation were considered: $\sigma_\theta = 0.15$ and 0.002, with $\sigma_\phi = 0.15$ constant. From top the panels in first and second row are for the non-rotating case, and third and last row panels are for the rotating case. In all the three cases of σ_θ, the intensity profiles in the rotating case were found to be shifted to the earlier phase whereas the polarization position angle profiles shifted to the later phase due to aberration. The phase shifts of the I peak in the cases of $\sigma_\theta = 0.15$ and 0.002 were found to be 1.36° and 1.24°, respectively. The phase shift of the I peak was found to decrease with decreasing σ_θ due to increase in the steepness of the modulation. Due to the combined effect of aberration and modulation, V is antisymmetric type in the case of $\sigma_\theta = 0.15$ but asymmetric in the positive and negative portions. In the extreme case of $\sigma_\theta = 0.002$, V becomes symmetric type, i.e., only strong positive circular survives. The simulations have reproduced for the first time this important result on the generation of symmetric type circular polarization.

In all the cases, the linear polarization L almost followed the total intensity except for its lower value due to incoherent addition of Stokes parameters within the beaming region. The polarization position angle swing is counter-clockwise, and the position angle inflection points (indicated by arrows) are found to be shifted to later phases by 3.42° and 1.00° in the rotating case. The phase shifts of the position angle inflection point was found to decrease with decreasing σ_θ due to combined effect of aberration and modulation.

(Dinesh Kumar & R. T. Gangadhara)

A search for intermediate mass black holes in globular clusters

A few globular clusters (GC) have been found to harbour a central black hole with suggested masses of a few hundred to thousand solar masses, which is intermediate between stellar-mass black holes and supermassive black holes (SMBH) that drive active galactic nuclei. The SMBH (both in active and non-active galaxies) show a well-established but intriguing relationship between the mass of the supermassive black holes and the mass and stellar velocity dispersion of the host galaxies. The intermediate-mass black holes of the GCs (IMBH) turn out to be consistent with the extrapolation of this relationship. Firm observational detection of such black holes in many GCs will improve the statistics and, if correlations persist, would imply that common mechanisms underlie the parallel growth of black holes and their hosts in both galaxies and globular clusters.

Most of the attempts to search for the central IMBHs in globular clusters, however, are not direct and present enormous observational difficulties due to the crowding of stars in the GC cores. Recently a new method of detection of the central IMBH in GCs by microlensing (ML) of the cluster stars was proposed, and an observational programme to search for ML signatures was initiated using the HCT and the VBT.

Data obtained from observations of the globular cluster NGC 5024 (M53) were used to tune the data-reduction pipeline, to build the analytical tools for

investigation of the complete time-series database and to test the feasibility of obtaining high-quality photometry in order to retrieve variable signals with the time scales and depth of typical GC stellar variability. A new pipeline based on an improved version of the differential imaging analysis developed by D. Bramich was applied in this work.

(M. Safonova, C.S. Stalin, N. Brosch, P. Shastri, M. Das, P. Hasan* & S. Raychaudhury*)*

Variables in the globular cluster NGC 5024

The globular cluster NGC 5024 (M53) was observed as part of the commissioning observations for the programme to search for intermediate-mass black holes in the centres of globular clusters via microlensing. The data obtained were used to identify variables in the cluster.

All known variables within the field of view were identified and periods and status of some previously reported short-period variables were revised. About seventy new variable sources were detected and their periods, light curves and possible types were derived. Out of these, 15 are SX Phe stars, 10 are W UMa-type stars and 14 are probable RR Lyrae stars. Nine of the newly discovered SX Phe stars and one eclipsing binary belong to the Blue Straggler Star (BSS) population.

(M. Safonova & C.S. Stalin)

Diffuse radiation field of the Galaxy

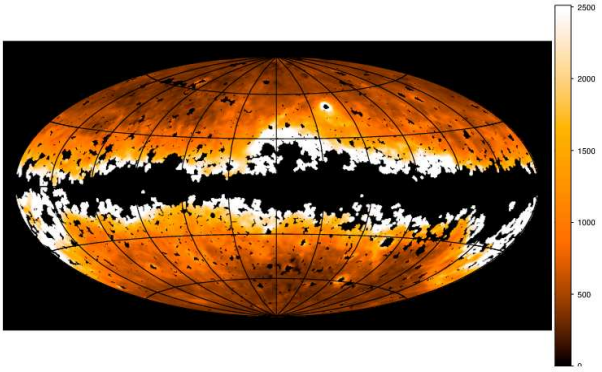

Figure 1.28: GALEX view of the ultraviolet sky.

The ultraviolet diffuse radiation field has been an outstanding problem in astrophysics for the last 40 years with implications on the interstellar medium and its morphology and on the extragalactic radiation, which might have been due to the integrated light of other galaxies. Data from the GALEX satellite have been critical in shaping our new understanding and have been used to construct the first map of the ultraviolet sky (see Figure 1.28). In addition to the drop-off of the radiation with distance from the Galactic plane, a number of small scale features have been seen, many of them previously unknown. Amongst these are the halos around nearby bright stars (Spica and Achernar), observed for the first time in the UV. These are due to the starlight scattered from thin dust clouds in front of, but near to, the star providing an unambiguous means of extracting the dust properties. Other recent results include a study of diffuse radiation from the Magellanic Clouds and the abundance of gas and its relation to dust in the interstellar medium.

(Jayant Murthy, A. C. Pradhan, V. S. Parvathi, N. V. Sujatha*, S. G. Guddenvar*, K. Preethi*, A. Pathak*, B. R. S. Babu*, N. Brosch*, R. C. Henry*, U. J. Sofia* & P. Shalima*)*

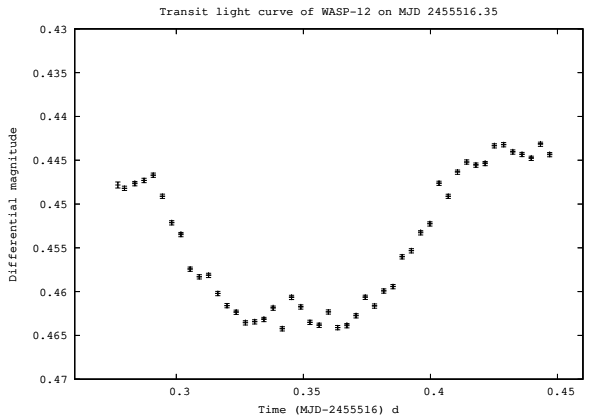

Figure 1.29: Light curve showing the transit of WASP-12b. The vertical axis gives the differential magnitude of this object relative to the total flux from several standard stars of constant magnitude in the field of view.

Exoplanet transit timing variations studies

The presence of multiple, hitherto undetected exoplanets orbiting their host star can cause variations in the transit time of a known exoplanet in that system. This transit time variation (TTV) can be particularly sharp over an interval of several transits, if the perturbing planet is in mean motion resonance with the transiting planet. TTV studies are the one

method to determine orbital and physical (mass, radius) characteristics of perturbing planets whose orbits are so inclined as to prevent any line-of-sight transits of the host star. We are observing transiting hot-Jupiters WASP-12 b, XO-3 b, HAT-P-16b, HAT-P-13b, and HAT-P-7b, all of which are likely hosts of multiplanet systems, over several transits taken over atleast 18 months, in order to detect or constrain the possibility of other planets in these systems, as well as to refine the orbital/physical characteristics of these objects. These measurements also test the sensitivity limits of the telescopes involved (in this case, the HCT). Shown in Figure 1.29 is one transit of WASP-12b, taken on 15/11/2010. The extracted transit depth of $\sim$ 15 mmag is as expected, and the errors in the measurements are $\leq$ 0.4 mmag. This light curve is now under further analysis to remove the non-linear trend, and to model the features seen during mid transit.

(F. Sutaria, A. Bhandare, N. Nanjundappa*, T. Sivarani, A. Goswami)*

1.3 Extragalactic Astrophysics and Cosmology

Structure of the Large Magellanic Cloud using red clump stars

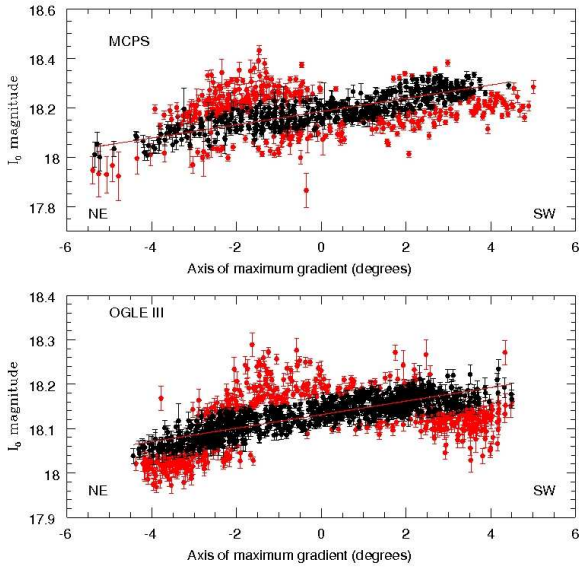

Figure 1.30: The surface plot of the LMC structure.

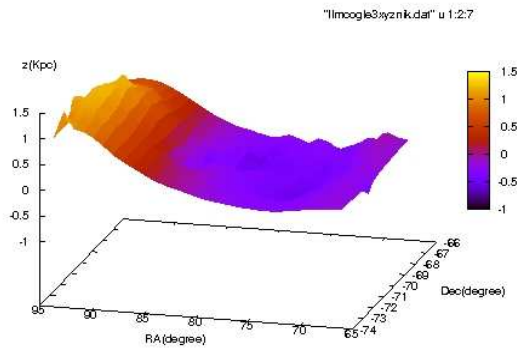

Figure 1.31: The location of warps shown in red points.

The Large Magellanic Cloud (LMC) is a nearby galaxy located at a distance of 50 kpc and is believed to be a disk galaxy. The LMC is known to have had interactions with our Galaxy as well as with the Small Magellanic Cloud. These interactions could have altered the structure of the LMC. The structural parameters of the LMC disk, such as the inclination, i and the position angle of the line of nodes, ϕ have been obtained by others using different tracers. The previously estimated parameters have a large range, with i ranging from 22^o to $35^o.8$ and ϕ ranging from $122^o.5$ to 170^o. In the present study the structural parameters using the red clump stars are estimated. The V and I bands data from the Optical Gravitational Lensing Experiment (OGLE III) survey for the study which gives a homogeneous and continuous sample are used. The red clump (RC) stars are core helium burning stars, which have a tightly defined colour and magnitude and are easily identifiable from the colour magnitude diagram. The dereddened peak I magnitude of the RC stars is used to obtain the relative distances and hence the z coordinate of different regions in the LMC. A weighted least-square plane-fitting method has been applied to the x,y,z data to estimate the structural parameters of the LMC disk. An inclination of i =$23^o.0\pm0^o.8$ and PA_{lon}, ϕ = $163^o.7\pm1^o.5$ is found for the LMC disk using the OGLE III data and an inclination of i=$37^o.4\pm2^o.3$ and PA_{lon} ϕ = $141^o.2\pm3^o.7$ for the LMC disk using the MCPS data. Extra-planar features, which are in front as well as behind the fitted plane, are seen in both the data sets. Regions in the northwest, southwest and southeast of the LMC disk are warped with respect to the fitted plane. A symmetric but off-centred warp (Figure 1.30) in the inner LMC has also been identified. It was found that the structure of the LMC disk inside the 3 degree radius is different from the outside disk in a way that the inner LMC has relatively less inclination and relatively large ϕ. The 3D plot (Figure 1.31) of the LMC disk suggests an off-centred increase in the inclination for the northeastern regions, which might be due to tidal effects. It is suggested that the variation in the planar parameters estimated by various authors as well as in this study is caused by the difference in coverage and the complicated inner structure of the LMC disk.

(S. Subramanian & A. Subramaniam)

Radio continuum and HI study of blue compact dwarf galaxies

The multifrequency radio continuum and 21cm HI observations were made of five blue compact dwarf (BCD) galaxies, Mrk 104, Mrk 108, Mrk 1039, Mrk 1069 and I Zw 97 using the Giant Meterwave Radio Telescope (GMRT). Radio continuum emission at 610 MHz and 325 MHz was detected from all the observed galaxies whereas only a few are detected at 240 MHz. In the sample, three galaxies

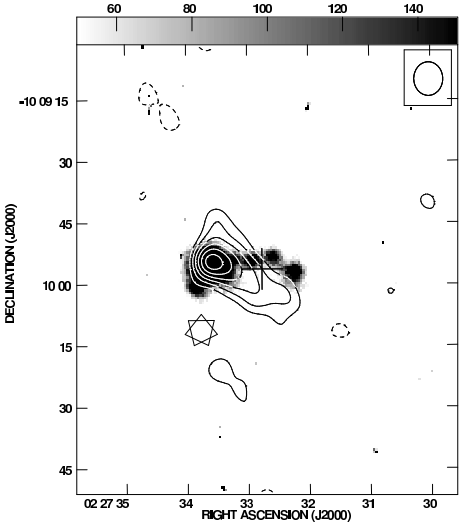

Figure 1.32: 610 MHz contours (GMRT) overlaid on continuum subtracted H_α image of Mrk 1039 taken from Himalayan Chandra Telescope. The radio continuum emission emanates from the bright star forming regions.

(Mrk 104, Mrk 108 and Mrk 1039) are members of groups and two (Mrk 1069 and I Zw 97) are isolated galaxies. The radio emission from Mrk 104 and Mrk 108 has been seen to encompass the entire optical galaxy whereas the radio emission from Mrk 1039, Mrk 1069, I Zw 97 was confined to massive HII regions. This indicates that the star formation in the latter group of galaxies has recently been triggered and that the environment in which the galaxy is evolving plays a role. Star formation rates calculated from 610 MHz emission is in the range 0.01 – 0.1 $M_\odot$/yr; this is similar to the star formation rates obtained for individual star forming regions in BCDs. The integrated radio spectra of four galaxies have been modelled over the frequency range where data was available. It was found that two of the galaxies Mrk 1069 and Mrk 1039, showed a turnover at low frequencies which was well fitted by free-free absorption whereas the other two galaxies, Mrk 104 and Mrk 108, showed a power law at the lowest GMRT frequencies. The flatter spectrum, localized star formation and radio continuum in isolated galaxies lend support to stochastic self-propagating star formation. The HI observations of four galaxies Mrk 104, Mrk 108, Mrk 1039 and Mrk 1069 showed extended disks as large as 1.1 - 6 times the optical size. All the observed BCDs (except Mrk 104) show rotating disk with a half power width of 50-124 km/s. Solid body rotation is common in our sample. The tidal dwarf origin was possible for two of the BCDs in the sample.

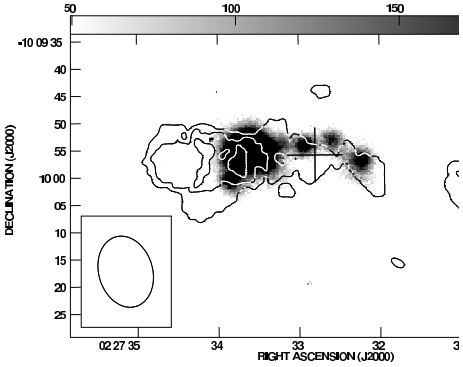

Figure 1.33: High resolution (10′ x 13′) neutral gas HI column density contours (GMRT) overlaid on continuum subtracted H_α image of Mrk 1039 taken from Himalayan Chandra Telescope. Column density of HI of 10^{21} cm $^{-2}$ is coincident with star forming regions implying a threshold for star formation to occur.

(S. Ramya, N. G. Kantharia & T. P. Prabhu*)*

AGN activity and black hole masses in low surface brightness Galaxies

Medium resolution optical spectroscopy of a sample of nine Low Surface Brightness (LSB) galaxies observed with the Himalayan Chandra Telescope (HCT), supplemented by the Sloan Digital Sky Survey (SDSS) data on some of the sources are used to look for signatures of Active Galactic Nuclei (AGN). LSB galaxies are extreme late spirals that have faint stellar disks but large gas disks that show little star formation. For those nuclear spectra that show clear signatures of AGN emission, the AGN component was separated from the stellar light due to underlying stellar population whose age was found to be between 1-4 Gyr. The H alpha line was decomposed into narrow and broad components, and the velocities of broad components was found to lie between 900–2300 km/s. Of the galaxies studied, UGC 6614, UGC 1922, UGC 6968 and LSBC F568-6 (Malin 2) show clear signatures of AGN activity. Approximate blackhole masses were calculated for these galaxies from the H alpha line emission using the virial approximation. The black hole masses lie in the range 10^5 – 10^6 $M_\odot$. Of the four detections, three have masses in the intermediate mass black hole domain rather than the supermassive range. The bulge stellar velocity dispersions were measured using the Calcium triplet lines for UGC 6614, UGC 6968 and LSBC F568-6 and plotted on the M- sigma plot. All the three galaxies lie below the M- sigma relation for nearby bright galaxies. Thus although the bulges

of LSB galaxies may be well evolved, their nuclear black hole masses have been lower than those found in bright galaxies and lie offset from the M-sigma correlation.

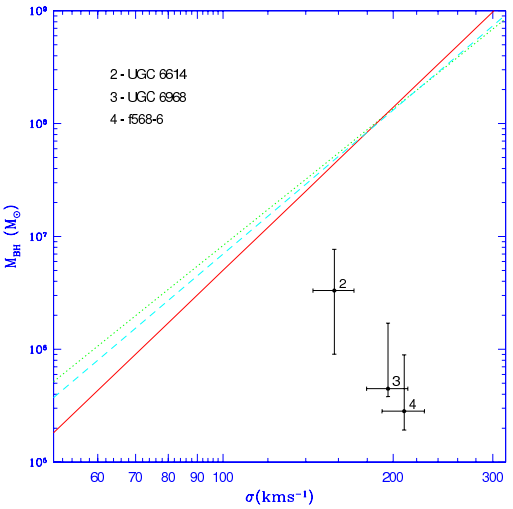

Figure 1.34: M(BH)-sigma plot for the GLSB galaxies, UGC 6614, UGC 6968, F568-6. GLSB galaxies fall lower than those found in bright galaxies and lie offset from the M-σ correlation for bright galaxies.

(S. Ramya, T. P. Prabhu & M. Das)*

Multi-wavelength studies of Active Galactic Nuclei

Mkn 421 is one of the nearby Active Galactic Nuclei of Blazar class, regularly observed by High Altitude Gamma Ray (HAGAR) facility at Hanle. This source was detected in a flare state during February, 2010. Light curve of Mkn 421 at energies above 250 GeV, obtained from HAGAR during 13th–19th February, 2010 was compared with light curves at lower energies obtained from archives of various satellites operating in soft X-ray (ASM onboard RXTE), hard X-ray (BAT onboard Swift) and gamma ray bands (LAT onboard Fermi). These light curves were examined for correlated variability and hint of correlation between variation of HAGAR detected flux and lower energy fluxes was seen. During these observations with HAGAR, Mkn 421 was detected at an average flux level equivalent to about 3 Crab units above 250 GeV, at a significance level of about 12 sigma in observation duration of about 9 hours. HAGAR flux reached the maximum value of 6 Crab units on 17th February, 2010. Multi-waveband spectral energy distribution including X-ray data from PCA onboard RXTE, lower energy gamma ray data from Fermi and very high energy gamma ray data from HAGAR was plotted for 17th February 2010 and was fitted with a Synchrotron Self Compton (SSC) model.

Analysis of HAGAR data on Mkn 421 for March and April, 2010 observation seasons showed continuous decrease in flux during February – April. This behaviour was consistent with the trend seen in soft X-ray data from ASM onboard RXTE. Similar analysis for HAGAR observations of Mkn 501 during March–June 2010 resulted in flux equivalent to about 1 Crab unit at a significance level of about 4.8 sigma in observation duration of about 10.5 hours.

(A. Shukla, V. Chitnis, P. R. Vishwanath, G. C. Anupama & T. P. Prabhu)

[Fe/H], [C/Fe], and [alpha/Fe] distributions of the Bootes I dwarf spheroidal galaxy

Near field cosmology with metal poor stars in the satellite galaxy of the Milkyway has been explored here. How similar metal poor stars of these satellites have been compared to the Galaxy halo stars. Based on the low-resolution spectral abundance study of 25 stars in the Bootes I dwarf spheroidal (dSph) galaxy, using LRIS instrument at Keck Observatory, the team derived [Fe/H], [C/Fe], and [alpha/Fe] for each star. It was found that both a large spread in metallicity (2.1 dex in [Fe/H]) as well as the low average metallicity in this system, ¡[Fe/H]¿ = -2.59, matched with the previous estimates. This sample included a newly discovered extremely metal-poor star, with [Fe/H] = -3.8, that is one of the most metal-poor stars yet found in a dSph. The metallicity distribution function of Bootes I was compared to analytic chemical evolution models. While the metallicity distribution function of Bootes I is best fit by an extra gas chemical evolution model, leaky-box models also provide reasonable fits. It was also found that the [alpha/Fe] distribution and the carbon-enhanced metal-poor fraction of the sample (12%) are reasonable matches to Galactic halo star samples in the same metallicity range, indicating that at these low metallicities, systems like the Bootes I ultra-faint dSph could have been contributors to the Galactic halo.

(D. K. Lai et al. & T. Sivarani)*

Study of X-ray spectral properties of Seyfert galaxies in the framework of the unification scheme

Seyfert galaxies are radio-quiet, low-luminosity ac-

tive galactic nuclei (AGN) hosted in spiral or lenticular galaxies. These galaxies are typcially categorised into two sub-types named as Type 1 and Type 2, based on the presence or absence respecively of broad permitted emission lines in their optical spectra. The unification scheme hypothesizes that these two subtypes are intrinsically similar and appear different solely due to differing orientations of the AGN, due to the presence of obscuring material with a toroidal geometry around the AGN. This hypothesis predicts that the X-ray emission from the central AGN would be attenuated and hardened when the obscuring material is in the line of sight, i.e., in the type 2 Seyferts. In order to test this prediction, the 0.5 – 10 keV X-ray spectral properties of a sample of Seyfert galaxies were studied, using observations from space-based XMM-Newton observatory. The sample was carefully chosen to have Seyferts of the two sub-types that were intrinsically similar. Spectral fits to the 0.5 – 10 keV X-ray data showed that the X-ray spectra of these Seyferts were characterized by a model that consists of an absorbed power-law, a narrow Gaussian fitted to the Fe K-alpha emission line at 6.4 keV, and an often seen soft-excess component characterized by either a thermal plasma model with temperature kT 0.1 – 1.0 keV and/or a steep power-law. As predicted by the unification scheme, the Seyferts of type 2 showed systematically lower soft-X=ray luminosities, higher absorbing column densities and larger equivalent widths of Fe Kα line.

(Veeresh Singh, Prajval Shastri & Guido Risaliti)*

Unveiling the nature of heavily obscured Active Galactic Nuclei

Active Galactic Nuclei (AGN) powered by accretion onto a supermassive black hole are believed to be surrounded by toroidal-shaped obscuring material. When the X-ray absorbing column density N_H (in terms of the equivalent hydrogen) is larger than $10^24\ cm^-2$, X-ray photons of energy below 10 keV are nearly completely absorbed and such sources have been known as Compton-thick AGNs. Thus X-ray observations sensitive only up to 10 keV such as from Chandra and XMM-Newton, are inefficient to study the nature of AGN and circumnuclear material in Compton-thick sources. While there is evidence in the literature that the Compton-thick AGNs do exist both in the local universe and at intermediate to high redshifts, and Compton-thick AGNs have been promising candidates to explain the spectrum of the X-ray background emission, only a handful of Compton-thick AGNs are known and well studied. Therefore the broadband X-ray spectral properties of the Compton-thick AGN NGC 5135 were investigated using Suzaku data. Spectral fitting to the 0.5 – 50 keV X-ray emission revealed that the absorbing column density towards the AGN is as high as 2.5 X 10 ^{2}4 cm^-2, and the intrinsic 2.0 - 10 keV X-ray AGN luminosity is nearly 100 times the observed value, consistent with the obscuring material being oriented nearly edge-on.

(Veeresh Singh, Guido Risaliti, Valentina Braito* & Prajval Shastri)*

Low-frequency radio emission properties of Seyfert galaxies

Seyfert galaxies are low-luminosity, radio-quiet (ratio of the 5.0 GHz radio flux to the B-band optical flux is less than 10) active galaxies. Radio emission at centimetre wavelengths is optically thin to obscuring torus and therefore, is effective in tracing the nuclear activity. Moreover, the high frequency radio observations are sensitive to high-surface-brightness radio emission which result in filtering out the low-surface-brightness extended emission. Authors study the low frequency radio spectral and imaging properties for a sample of Seyfert galaxies using 610/240 MHz GMRT observations and 1.4 GHz VLA archival data. The primary objective of the study was to test the Seyfert unification model at low-frequency radio regime. However, the nature and origin of low-frequency radio emission in Seyfert galaxies is also being investigated. Results based on multi-frequency radio study showed that both Seyfert Types 1 and 2 have similar distributions of radio luminosities and radio spectral indicies, consistent with unification scheme.

(Veeresh Singh, Prajval Shastri & Ramana Athreya)*

X-ray and optical properties of broad absorption line quasars in CFHTLS

Broad absorption line (BAL) quasars are active galactic nuclei (AGN) characterized by the presence of strong absorption troughs in their ultraviolet (UV) spectra. They constitute an observed fraction of about 10-15 percent of optically selected quasars. The dichotomy between BAL and non-BAL quasars is often thought to be a consequence of orientation. Still there is no clear picture of the physics of outflows/winds in BALs. BAL quasars which are radio quiet have been known to have faint soft X-ray-to-optical luminosity ratio. Their X-ray luminosity

is typically 10-30 times lower than expected from their UV luminosity, qualifying them as soft X-ray weak objects. This implied that the soft X-ray continuum of BAL quasars was either (i) strongly absorbed by highly ionized material or (ii) intrinsically underluminous. This issue of the X-ray weakness of BAL quasars has been investigated using a new sample of quasars selected in the Canada-France-Hawaii Telescope Legacy Survey (CFHTLS) and overlapping the XMM Large Scale Structure Survey (XMM-LSS) and the Spitzer Wide-area InfraRed Extragalactic (SWIRE) survey with the aim of (i) identifying a homogeneous sample of BAL quasars from a parent quasar sample and (ii) studying the X-ray nature of those identified BAL quasars. The sample has been selected without a prior knowledge of the BAL nature of the objects. The mean observed X-ray-to-optical spectral slope (α_{ox}) for the X-ray detected non-BAL and BAL quasars were found to be -1.47 $\pm$ 0.13 and -1.66 $\pm$ 0.17 respectively. It was also found that this new sample of BAL quasars had X-ray luminosity a factor of 3 smaller than that found for non-BAL quasars of similar optical luminosities.

(C. S. Stalin, R. Srianand & P. Petitjean*)*

The WIRCAM Deep Infrared Cluster Survey. I. Groups and clusters at z > 1.1

Using a combination of XMM-Newton X-ray data and optical/NIR photometry, a survey of z > 1.1 cluster candidates were carried out in the CFHTLS D1 (Deep-1) and D4 (Deep-4) fields. Crucially, NIR data was required in order to apply the red-sequence analysis at such redshifts (as the 4000Å break moves out of their optical into the NIR bands). As such, the WIRcam Deep Survey (WIRDS) data, which provided the best combination of wide field and deep NIR data currently available, was one of the best resources for the identification of high redshift clusters. Using the WIRDS data in conjunction with CFHTLS deep optical photometry, a total of 15 z > 1.1 cluster candidates were identified in a total area of 1.0 deg^2. All candidates were selected based on X-ray emission in deep XMM data, which provides a relatively unbiased sample. Of the 15 cluster candidates, 7 were considered firm candidates.

(R. M. Bielby, A. Finoguenov*, M. Tanaka*, H. J. McCracken* et al., R. Srianand*, C. S. Stalin & C. J. Willott*)*

Mass of the black hole in the Seyfert 1.5 galaxy H 0507+164 from reverberation mapping

It is now believed that the source of activity in galaxies, (commonly called Active Galactic Nuclei) is due to the accretion of matter onto the Super Massive Black Holes (SMBH) located at the centre of those galaxies. Reverberation mapping is one of the many methods by which the mass of this central SMBH in AGN can be estimated. The reverberation mapping technique works on the following principle. In the optical bands, the continuum flux of some AGNs show variations on various timescales. These continuum variations were seen in the broad emission lines in the AGN spectra with a time lag (τ), and this time lag was due to the light travel time across the broad line region (BLR). Measurement of this time lag led to an estimate of the size of the BLR as $R_{BLR} \leq c\tau$. Assuming virial equilibrium, using the velocity dispersion of the broad component of the emission lines and the estimated radius of the BLR, the mass of the black hole could be estimated. To estimate the mass of the BH using the technique of reverberation mapping in the Seyfert 1.5 galaxy H 0507+164, a total of 22 epochs of spectra were taken using the 2m HCT during the period 21st November and 26th December 2007. A time delay of of $\tau = 3.01^{+0.42}_{-1.84}$ days was found in the rest frame of the quasar for the H_β line fluxes to respond to the variations in the optical continuum at 5100Å. Using this time delay and the width of the H_β line, a black hole mass of $9.62^{+0.33}_{-3.73} \times 10^6 M_\odot$ was found for this source.

(C. S. Stalin, S. Jeyakumar, R. Coziol, R. S. Pawase* & S. S. Thakur*)*

Spin-down of black holes and cosmic evolution of AGN

Work is in progress on a self-consistent model of the evolution of black hole spin and mass. It is planned to compare this with fully relativistic, axisymmetric simulations of a non-radiative, magnetized plasma onto a Kerr-Schild black hole within the MHD approximation.

(A. Mangalam)

Models for X-ray & Optical Light curves from Black Hole Systems

Analysis of light curves from active galactic nuclei are considered, comparing a wide variety of time series analysis techniques that have been used in the literature. Useful properties from light curves by pro-

gramming, testing and applying implementations of the following time series techniques: wavelets, periodograms, Lomb-Scargle periodograms, structure functions and multi-harmonic analysis of variance have been derived. A unified noise model used in these analyses in order to confirm a detection with consistency and to rule out spurious detections have been discussed. Applications of all these techniques to X-ray light curves have yielded consistent short time-scale quasi-periods of ~ 1045 s and 2091 s (S5 0836+716) in a sample of 15 light curves from various active galactic nuclei (AGN) extracted from the XMM-Newton archival database. In addition, intra-day variability (IDV) time-scales of 25050 s (IRAS 13224−3809), 26800 s (1ES 1028+511) and 14200 s (S5 0716+714) have been determined using the structure function. Although such short time-scale variations are more likely to arise from a relativistic jet in blazars, the only model that can be cleanly analysed assumes that they arise from orbital signatures some location between a few and 100 gravitational radii around the central black hole; adopting such a model places a lower limit on the mass to be $> 0.68 \times 10^5 M_\odot$.

Theoretical models are being built for signatures of relativistic flow near the innermost stable circular orbit and also jet based models of helical flow to explain the QPO activity.

(Prashanth Mohan, A. Mangalam, A. C. Gupta & P. J. Wiita*)*

Particle injection spectra in high$-z$ radio galaxies

The question of the relativistic electrons in high-redshift radio galaxies injected with very steep energy spectra has been examined. Based on theoretical arguments it was argued that the electron spectral energy index at high redshift was mostly due to synchrotron losses modified by red shift correction and inverse Compton losses. The possibility of the first order Fermi acceleration process was discounted. Empirical and observational support for this result by using RM measurements that is a tracer of ambient electron density is being found.

(A. Mangalam & Gopal Krishna)*

1.4 Atomic and Molecular Physics

Atomic clocks

A general order relativistic coupled-cluster theory has been developed for high precision calculations of atomic and molecular properties. This theory has been applied to determine the black body radiation shift of the Al+ clock, which is currently the most accurate atomic clock. The results obtained by the authors reduces the systematic errors in this clock by 28%.

In the calculation mentioned above, one, two, three and four hole-particle excitations have been used. This is the first relativistic coupled-cluster calculation to be performed using three and four hole-particle excitations. It is also the first relativistic coupled-cluster calculation where polarizabilities have been calculated using the linear response theory.

(B. P. Das, M. Kallay, H. S. Nataraj*, B. K. Sahoo* & L. Visscher*)*

Ultracold atoms

The quantum phases of ultracold bosonic atoms in a periodic one dimensional optical superlattice have been studied. Starting from the Mott insulator phase, the superfluid phase as well as novel Mott insulator phases with density wave order by varying the strength of the superlattice potential have been obtained. It was also found that one of the latter kinds of Mott insulator co-exists with the superfluid phase at an incommensurate density. The calculations for the above study was carried out using the density matrix renormalization group.

(Arya Dhar, B. P. Das, T. Mishra & R. V. Pai*)*

Ultracold molecules

Theoretical studies of the ground and excited states of LiYb have been performed for assessing the feasibility of the formation of this molecule by photoassociation. Second order relativistic complete active space perturbation theory was used for the calculations. These results will be useful to experimentalists working on ultracold LiYb.

(B. P. Das, G. Gopakumar, M. Abe*, M. Hada* & K. Hirao*)*

Study of potential energy surface and molecular geometry using post-mean field method

The development and largescale implementation of refined and efficient MR-based perturbation theories (termed as state specific MRPT, SS-MRPT) methods have now been at the forefront. Philosophically, Hilbert space MR methods have been effective to compute potential energy surface (PES). The computation of smooth and spectroscopically accurate PES via an efficient MRPT method is the prime aim in the ongoing research works. The effective Hamiltonian-based Hilbert-space methods simultaneously converge wave functions for entire sets of electronic states with the same number of electrons, yielding an excitation energy spectrum within a single computation; in essence, these methods are multi-reference, multi-root schemes suitable for mapping a manifold of potential energy surfaces. The application of Hilbert-space methods has been plagued by intruder state problems, occurring when a determinant outside the model (reference) space closely approaches the energy of a state inside this space at some point on a potential energy surface. Intruder states may not only spoil the convergence of multi-reference, multi-root procedures but may even lead to unphysical features on computed potential energy surfaces. Such difficulties, coupled with the need for multi-reference, state-specific MR theories (SS-MR) for treating one electronic state at a time, have spawned new formal developments.

(Uttam Sinha Mahapatra, Sudip Chattopadhyay* & Rajat Kumar Chaudhuri)*

Development and application of relativistic many-body theory

Ionization potential (IP) and excitation energies (EEs) of Indium atom (In I) was computed using the valence universal multi-reference coupled cluster (VU-MRCC) method with the four-component relativistic spinors. The effect of electron correlations on the ground and excited state properties have been investigated using different levels of CC approximations and basis sets. The present study shows that for a given basis the linearized VU-MRCC method tends to underestimate the IP, EEs and other one-electron properties such as magnetic hyperfine constant (A) compared to the full blown VU-MRCC method. The IP, EEs, A and oscillator strengths (f) determined at VU-MRCC level are in excellent agreement with experimental data. The properties reported further

demonstrated that basis set with at least h-type of orbitals was required to achieve converged results.

(Madhulita Das, Rajat Kumar Chaudhuri, Sudip Chattopadhyay & Uttam Sinha Mahapatra*)*

The spin-rotational Hamiltonian parameters $A_{\parallel}$ and $A_{\perp}$ for BaF molecule were calculated using four component relativistic spinors at second order many-body perturbation theory (MBPT) level via Z-vector technique. The second order MBPT was applied to assess the accuracy of the computed hyperfine structure constants before studying the problem with the *state-of-the-art* CCSD method which is highly accurate but computationally more expensive than MBPT. The hyperfine structure constants A and A_d resulting from these calculations agree favorably well with experimental findings and with other correlated calculations. The convergence behavior of A and A_d with respect to the number of active orbitals used in the perturbative calculations suggests that the estimated A and A_d values should be accurate.

(Malaya K. Nayak & Rajat Kumar Chaudhuri)*

Non-Accelerator Particle Physics

The relativistic coupled-cluster theory has been applied to the EDM of atomic thallium (Tl) to determine the enhancement factor (ratio of atomic EDM to the electron EDM) of this factor. The strong electron correlation effects for this property were calculated to an accuracy of 2%. The result for our enhancement factor was combined with the measurement of the EDM of atomic thallium to obtain a new limit for the electron EDM. This limit could have important implications for physics beyond the standard model and matter-antimatter asymmetry in the universe.

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

1.5 Optical Sciences

Spectro-polarimetery with NLST: Evaluation of seeing induced crosstalk errors

The measurement of the complete polarization state of solar line profiles is required to infer the strength and orientation of magnetic fields at the solar surface. In order to have good spatial and spectral resolution in the measurements, a large aperture solar telescope such as the proposed NLST in combination with array detectors is required. However, the spatial resolution in such measurements is affected by atmospheric seeing. Adaptive optics, which is an integral part of any large telescope, will minimize such effects. In polarimetry, crosstalks are defined as the intermixing of the four Stokes vector I, Q, U and V as a result of an imperfect measurement process. The sources of this error are the incomplete calibration of the telescope-polarimeter system and the fluctuation in the signal due to atmospheric seeing. The former could be estimated by calibrating accurately the telescope-polarimeter system using calibration optics placed very close to the prime focus. In order to understand the crosstalk produced by the latter, the effect of seeing on the polarimetric measurement process was quantitatively studied. The atmospheric induced crosstalk errors among the Stokes I, Q, U, and V parameters using the formalism already developed by Lites (1987, LEST Found., Tech. Rep., No. 23, 35 pp) are analyzed. The power spectrum of the Fried's parameter r_0 obtained from the solar differential image motion monitor (SDIMM) at the Merak site, the candidate site for proposed NLST, was used in this formalism.

(Neeharika Sinha, Rajendra B. Singh, K., Sankarsubramanian, S. P. Bagare, K. E. Rangarajan & S. S. Hasan)*

Thermal characteristics of a classical solar telescope primary mirror

The primary mirror heating of a solar telescope mirror caused by the light absorption is a complex and challenging problem for optical engineers. The thermal performance of a solar telescope mirror needs to be accurately predicted under real observing conditions. In this work we have outlined an approach to study the thermal and structural response of a primary mirror blanks made of SiC and Zerodur materials. The heat transfer model realistically describes the nonuniform mirror heating and temperature gradients caused by a smooth and gradual increase of the solar flux during the day and convective and radiative cooling during the night. The low thermal conductivity of Zerodur mirror gives rise to strong radial and axial temperature gradients that are quite distinct for the day-time heating and night-time cooling. Heat loss by free convection is very slow so the mirror retains significant heat during the night. The thermal response of the SiC mirror is significantly different from the Zerodur. The temperature within the SiC mirror substrate equilibrates rather quickly due to high thermal conductivity. The absence of thermal gradients and the advantage of high thermal conductivity of SiC cannot be favorably leveraged without some temperature regulation by external means. Further, the finite element structural model was used to predict the temperature induced mechanical deformations of mirror blanks. The optical surface errors resulting from mirror expansion or contraction were analyzed by mapping the temperature patterns from the solution of the thermal model to the structural model. These studies are important a) to design an efficient thermal control system for the primary mirror of the solar telescope and b) to evaluate the effect of mirror seeing on the telescope performance if it were to be utilized for night-time astronomy.

(Ravinder Banyal & B. Ravindra)

Non-linear response studies and correction for a liquid crystal spatial light modulator

Liquid crystal (LC) based spatial light modulators (SLM) are pixelated electro-optic devices that are capable of modulating the phase, polarization or intensity of light according to a desired spatial and temporal pattern. In addition to the control voltage, the intensity transmitted by the LC cell is influenced by several factors. These include the effect of signal conditioning by the graphics board, the brightness and contrast control settings of the projector and the relative orientation of the polarizer and the analyzer. Experimental studies were conducted to study of the light transmission characteristics of a commercially available SLM. Intensity and phase modulation characteristics were measured by sandwiching the LC-SLM between a polarizer (P) and an analyzer (A). The results indicate a highly nonlinear (input/output) response of the device. Measured intensity modulation curves are best described by either power-law or Sigmoidal functions. Based on the power-law transformation, an appropriate preprocessing of input gray-scale images is suggested.

The parameter space that provides a useful (linear) range of operation was identified to make use the existing SLM in different optical experiments in the laboratory.

(Ravinder Banyal & B. Raghavendra Prasad)

Measurement of the influence function of a deformable mirror using a microlens array

Deformable Mirrors (DMs) have been widely used as wavefront correctors and phase production devices in adaptive optics applications. The characterization of the Continuous membrane Deformable Mirror (CDM) involved the measurement of the influence function, estimation of inter-actuator coupling coefficient and determination of the interaction matrix. The shape of the surface deformation of the CDM was obtained using a microlens array and a CCD. The measured influence function was fitted using a Gaussian function and also decomposed into Zernike moments.

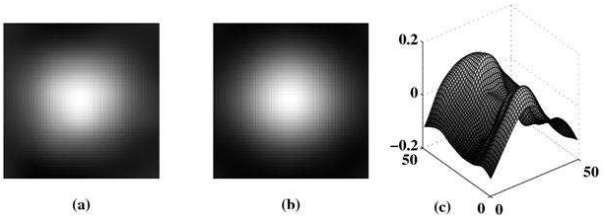

Figure 1.35: (a) Influence function for actuator 66: Bias voltage = 0V, Voltage applied = 20V, size in pixels: 50 X 50, number of subapertures -25 X 25, (b) Mean Influence function excluding edge actuators (c) Residual error for the Gaussian fit.

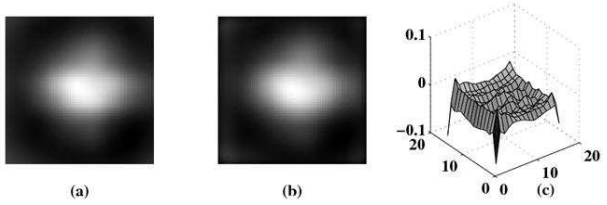

Figure 1.36: (a) Influence function for actuator 66: Bias voltage = 50V, Voltage applied = 30V, size in pixels: 64 X 64, number of subapertures–25 X 25, (b) Zernike fit of the sample influence function using n=20 radial orders of Zernike moments, (c) Residual error for the Zernike fit.

The continuous membrane surface deformable mirror that was used in the experiment was a 140 actuator Multi-DM from Boston Micromachines Corporation, with a maximum stroke of 5.5 μm. The CDM surface was recorded by poking all the actuators individually and giving a constant bias voltage to the remaining actuators. The mean influence function was then obtained. The inter-actuator coupling was found to be 33 % in 'x' direction and 18 % along 'y' direction. The sample influence function was Gaussian fitted. The influence function was also fitted using Zernike polynomials. The fit error in this case reduced exponentially as the number of Zernike moments was increased. Figure 1.35 shows a sample influence function, Gaussian fit to the mean influence function and the residual error of the fit in case of zero bias voltage. Figure 1.36 shows a sample influence function, its Zernike decomposition and residual error for the case of a bias voltage of 50V. Zernike decomposition yields superior performance for non-zero bias voltage. Also, the obtained interaction matrix demonstrates the localized effect of CDM actuators.

(M. B. Roopashree, Akondi Vyas & B. Raghavendra Prasad)

Evaluation of centroiding algorithms in a Shack Hartmann sensor

The error budget in a Shack Hartmann type wavefront sensor was shared by the inaccuracies in the centroiding and wavefront reconstruction algorithm. The centroiding inaccuracies depended on the incident light intensity, photon noise, readout noise and background noise. Experimental comparison of two centroid detection algorithms, simple centre of gravity (CoG) and weighted centre of gravity (WCoG), was performed. A numerical evaluation of these algorithms suggested that their performance depended strongly on light intensity and noise levels.

A low resolution Zernike polynomial (Z104) was addressed on the Deformable Mirror (DM). The wavefronts were reconstructed using CoG and WCoG methods. The effect of the readout noise was tested by performing multiple reconstructions of the same wavefront distortion. It was found that the readout noise does not significantly affect the reconstruction accuracy in our wavefront sensing experiment and the percentage error in the wavefront reconstruction accuracy due to readout noise was found to be ∼0.24%.

Background noise was introduced using a transmitting type spatial light modulator (SLM). The introduction of random noise on the SLM pixels gave rise to a mean reconstruction accuracy of 0.70580.0397 (∼22 times readout error) for CoG method and 0.70550.0107

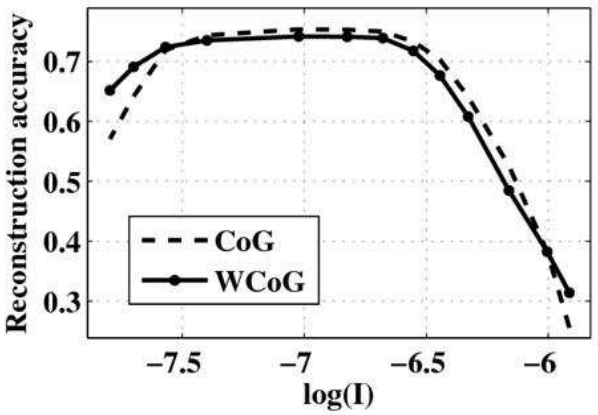

Figure 1.37: A logarithmic plot of wavefront reconstruction accuracy at different intensity levels to compare CoG and WCoG methods

(∼6 times readout error) for WCoG case at a measured input power, I = 0.18 μ W. It can be noted that at high intensity levels, when the CCD goes near saturation (I > 1μW), WCoG performs better than CoG algorithm. Also, at low light level conditions (I < 0.04 μW), WCoG does a better job than CoG method. However, at good light levels (at I = 0.69 μ W), CoG performs nearly 7.1 % better than WCoG as shown in Figure 1.37. Wavefront distortions following Kolmogorov turbulence statistics were simulated through the calculation of Zernike moments and were imposed on the DM (lower Zernike orders (n<3) were not used). The wavefront sensing abilities remained the same.

(M. B. Roopashree, Akondi Vyas & B. Raghavendra Prasad)

Data stream mining and servo lag error minimization in adaptive optics

Prediction of the wavefronts arriving at a later time helps reduce the servo lag error in adaptive optics caused by finite time delays (1-5 ms) before wavefront correction. Piecewise linear segmentation based prediction cannot adapt to randomly fluctuating turbulence statistics of the atmosphere. This problem was addressed by adaptively changing the prediction parameters through the application of data stream mining on wavefront sensor data obtained in real-time. Numerical experiments suggest that pixel-wise prediction of phase screens and slope extrapolation techniques lead to same improvement while modal prediction is sensitive to the number of moments and can yield better results with optimum number of modes.

Monte Carlo simulations were performed on phase screens simulated which include the fluctuations in the data stream parameters in time. A comparison of a simple prediction methodology and data stream mining based prediction is shown in the Figure 1.38.

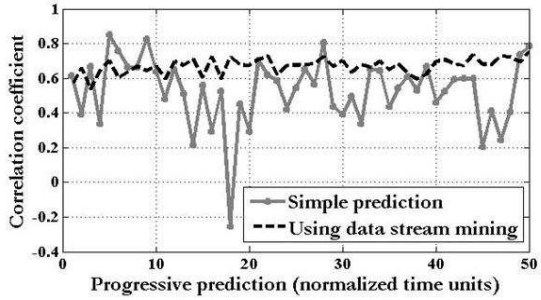

Figure 1.38: A logarithmic plot of wavefront reconstruction accuracy at different intensity levels to compare CoG and WCoG methods

Pixel-wise linear predictor is a lossless predictor, although computationally challenging, where the computational time involved increases linearly with the number of pixels to be predicted. Slope extrapolation is a prediction methodology where the information that is available is the local slopes measured via a SHS. Modal prediction is yet another prediction methodology where the number of elements is determined by the number of orthogonal modes (N) to be used to represent the phase screen reasonably accurately. It was observed that the performance of the pixel-wise prediction overlaps with the slope extrapolation method. Modal prediction (N = 72) in this case gives better results when compared with slope extrapolation and pixel-wise prediction methods.

(Akondi Vyas, M. B. Roopashree & B. Raghavendra Prasad)

Noise reduction in MEMS based deformable mirror images using intensity weighting

The frames captured with a compact, high-resolution, monochrome progressive scan CCD camera, of a continuous facesheet microelectromechanical systems (MEMS) deformable mirror (DM), include unwanted diffractive, background and readout noises; which significantly reduced the quality of imaging in many applications. Processing these images before passing them on to meet later experimental objectives could improve its performance greatly.

A continuous membrane DM (CDM) which has

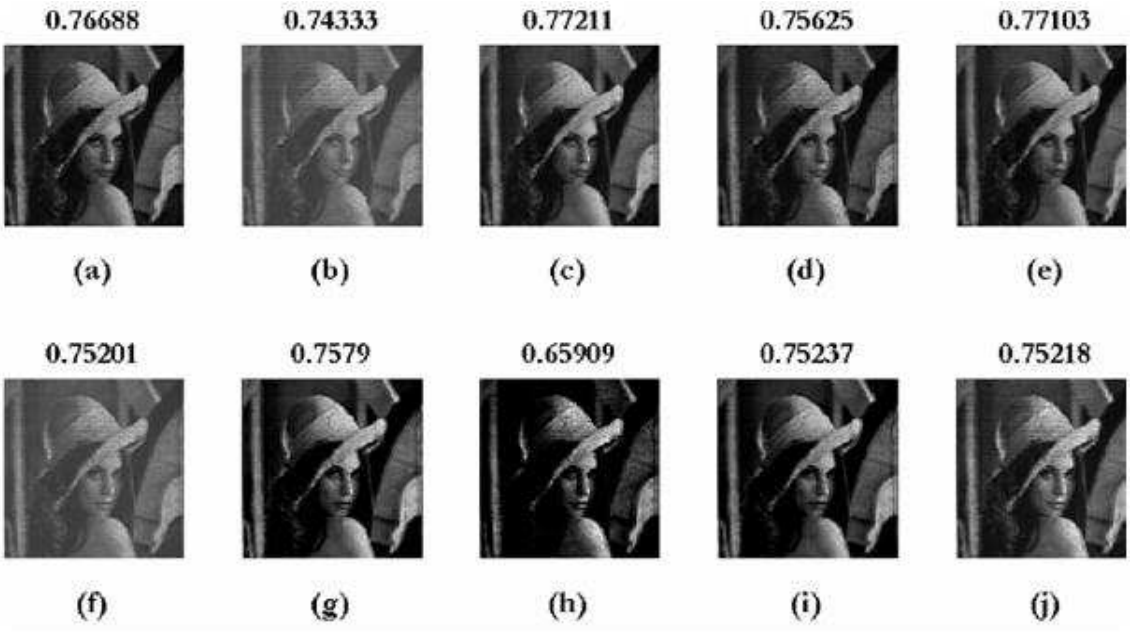

Figure 1.40: Images obtained after applying intensity weighted noise removal on images. Intensity weighted noise removal algorithm applied for the (a) case of bright background removal (b) case of dark background removal (c) bright background: median filtering applied (d) dark background: median filtering applied (e) bright background: wiener filtering applied (f) dark background: wiener filtering applied (g) contrast improved: bright background median filter (h) contrast improved: dark background median filter (i) contrast improved: bright background wiener filter (j) contrast improved: dark background wiener filter. The correlation coefficient of the above images with the actual image is given above every image.

140 actuators in a 12 X 12 grid with fixed corners was used. The images captured during experiments where CDMs are involved contain several noise effects which include unwanted diffractive noises. Although the CDMs are manufactured such that the actuators maintain a minimal contact with the mirror bottom surface, minor features on the DM surface are captured by the charged coupled device (CCD), and hence post-processing of these images is a requirement. These features have been attributed to the presence of actuator posts which hold the DM membrane. In case where the CCD was not in the image plane of the CDM, the image quality reduced further due to the presence of prints due to actuator posts on the image.

The experimental work was aimed to capture images from an optical arrangement involving a CDM and to reduce the noise effects using a suggested series of steps, largely based on standard image processing techniques and a noise removal method based on image intensity weighting. A liquid crystal (LC) based spatial light modulator (SLM) was used in our experiments to project reference images.

Bright and dark background images were taken. Here, bright background corresponded to the image captured by allowing all the pixel values on the SLM to take the maximum value (gray level = 255). Dark background corresponds to a zero gray level for all the SLM pixels. It can be noted from Figure 1.40 that using the intensity weighting noise removal technique significantly improved the image quality as compared to simple subtraction method illustrated in Figure 1.39.

(Akondi Vyas, M. B. Roopashree & B. Raghavendra Prasad)

Light scattering by rough surfaces: detection of periodicities, hidden behind randomness

Periodic structures, embedded on plane surfaces cannot be detected by light scattering studies, if these structures are also smeared by a sufficiently strong background randomness. This happens because the Bragg peaks due to the periodic part are sufficiently broadened by the strong phase structure function of the randomness, making the peaks undetectable. The extended matched filter method developed by us, allows one to reveal the peaks, in situations where

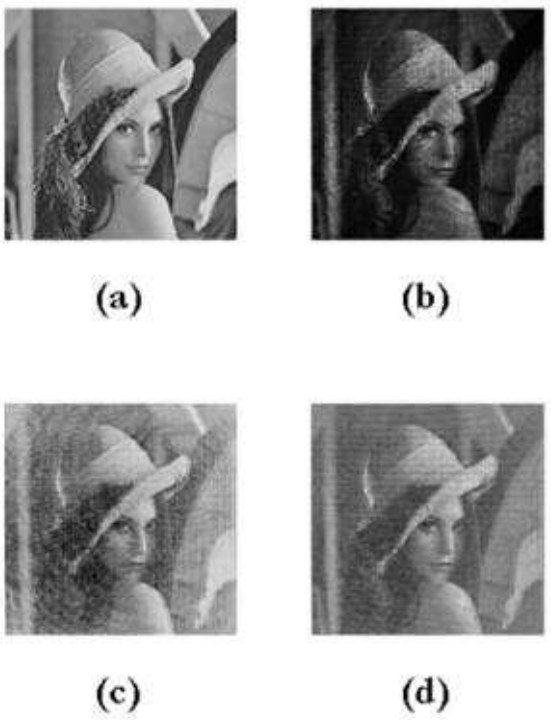

Figure 1.39: (a) Actual image, correlation coefficient (c) = 1.0000 (b) Image captured by the CCD, c = 0.6778 (c) Resultant image after simple subtraction of bright background, c = 0.6146 (d) Image obtained after subtracting the dark background, c = 0.7121.

the conventional methods would fail. This is done by an algorithm, which removes the strong $n = 0$ peak and thus reveals the two peaks for $n = +1$ and $n = -1$ cases, which are thus sufficiently separated. While the strong $n = 0$ peak is separated from the weaker $n = \pm 1$ peaks by wave vector $v = 2\pi/\Lambda$, the separation between the $n = \pm 1$ peaks is $v = 4\pi/\Lambda$, where Λ is the wave length of the periodic part. With the $n = 0$ peak being removed, from the intensity pattern, the $n = \pm 1$ peaks are thus more easily resolved. This method, which tries to circumvent the limitations of the Rayleigh criterion, uses the peak profiles to be of the type, $f(v) = [1 + (r_0^2/2y)v^2]^{-y}$, which is capable of describing a wide variety of cases of light scattering by roughness. We have verified that for the random elevations $\zeta(r)$ on the surface, a wide class of correlation functions of the type, $< \zeta(0) \cdot \zeta(r) >= \sigma^2 \exp[(-r/l)^\beta]$ would give a profile structure like the $f(v)$ given above. In every case, we could relate r_0 and y with σ, l, β and the wave length of light, λ. The applicability of our extended matched filter method was seen to be more effective for the detection of hidden periodicities, than what would be allowed, when the detection mechanism is bound by the limitations of the Rayleigh criterion. This method can be specially applied for detection of structures, smeared by randomness and has potential application in fabrication of optical and electronic components.

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

X-ray attenuation coefficients of mixtures

The Dual Energy Computed Tomography (DECT) is emerging as an effective non-invasive method for the detection of hidden objects, yielding also the knowledge of the chemical compositions of these objects. The CT method, which emerged from the basic ideas of radio-astronomy (R.N. Bracewell) and electron microscopy (G.N. Ramachandran), gives only the physical shapes of the objects. The DECT method, aimed to find the chemical compositions of these objects, uses in addition, the X-ray attenuation coefficients of atomic systems. The attenuation coefficients of atoms are known to be a linear sum of those due to (1) the Compton scattering part and (2) photoelectric effect. The former is proportional to $\rho_e f_{\rm KN}(E)$, where ρ_e is the electron density of the material and $f_{\rm KN}(E)$ is the Klein-Nishina formula, E being the energy of the photon. The photoelectric part is proportional to $\rho_e Z_{eff}^x / E^y$ where Z_{eff} is the effective atomic number of the substance with x and y being some characteristic exponents. To know, the two unknowns, ρ_e and Z_{eff}, two independent experiments at two different energies are needed. For inversion, where averaging over the X-ray source spectrum is essential, conventional methods use, $f_{\rm KN}(E) = 1.0$ and use various different values for the exponents, x and y, with $3.0 \leq x \leq 4.0$ and $3.0 \leq y \leq 3.5$. While such wide freedom with adjustable parameters enables one to fit a wide range of data, the calculated values of ρ_e and Z_{eff} are fraught with errors due to inaccuracies in the choices of parameters that are used in the inversion process. From the study of published data (NIST tables) we have concluded that for the photon energy, used by the CT machines, (1) the full Klein-Nishina formula has to be used, (2) $y = 3.0669$ (no ambiguity to be allowed) and (3) $2.45 \leq x \leq 2.75$ for most of the atomic systems of low Z value. Also from our experimental studies, we found that for mixtures, the exponent x depends in a sensitive way on the composition of the mixture.

(Rezvan Ravanfar Haghighi, S. Chatterjee, Akondi Vyas, Pratik Kumar* & Sanjay Thulkar*)*

Speckle imaging with hypertelescope

Optical stellar interferometers have demonstrated milliarcsecond resolution with few apertures spaced hundreds of meters apart. To obtain rich direct images, many apertures will be needed, for a better sampling of the incoming wavefront. The coherent imaging thus achievable improves the sensitivity with respect to the incoherent combination of successive fringed exposures, heretofore achieved in the form of optical aperture synthesis. For efficient use of highly diluted apertures, this could also be done with pupil densification, a technique also called "hypertelescope imaging". Although best done with adaptive phasing, concentrating most energy in a dominant interference peak for a rich direct image of a complex source, such imaging was also possible with random phase errors such as caused by turbulent "seeing", using methods such as speckle interferometry and speckle imaging. Such observations have been simulated using an aperture which changed through the night, as naturally happens on Earth with fixed grounded mirror elements, and find that reconstructed images of star clusters and extended objects were of an unprecedently high quality. As with cophased imaging with these telescopes, speckle imaging was also constrained by the field of view limitations. Also it was shown that with utilizing the aperture rotation of the diluted array through the night, reconstruction quality could be increased substantially.

(A. Surya, S. K. Saha & A. Labeyrie)*

Tomographic speckle imaging

The triple correlation technique is a third-order moment (Bispectrum) analysis yielding the phase allowing the object to be fully reconstructed. The advantages of this technique are of providing (i) information about the object phases with better S/N ratio, (ii) means for recovery with diluted coherent arrays owing to its relationship with the phase closure technique used in radio astronomy and optical aperture synthesis techniques. The disadvantage of this technique was that of demanding very severe constraints on the computing facilities with 2-dimensional data since the calculations were 4-dimensional. It required extensive evaluation-time and data storage requirements, if the correlations were performed by using digitized images on a computer. Tomographic methods using Radon transform offer a better alternative since they are computationally efficient. Both Direct Bispectrum and Radon transform based triple correlation algorithms have been developed to process the speckle frames. The developed algorithms were applied to the simulated speckle images from IMAGIN, which is a numerical simulation developed for multi-aperture imaging in cophased and speckle mode. The mode of beam combination used was Fizeau mode. The results of the simulations of image reconstructions showed that tomographic speckle imaging provided a computationally efficient alternative to Direct Bispectrum technique with Fizeau imaging optical interferometers.

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Paper Presentations in Meetings

G. R. Gupta presented the following papers: "1st Asia-Pacific Solar Physics meeting", 21st – 24th March, 2011, Indian Institute of Astrophysics, Bangalore *Presence of Torsional Alfvén Waves in Polar Coronal Hole Regions*; "13th Young Astronomer's Meeting", 3rd – 5th September, 2010, Physical Research Laboratory, Ahmedabad,*Propagating MHD Waves in the Solar Atmosphere*; "38th COSPAR Scientific Assembly", 18th – 25th July, 2010, Bremen, Germany titled *Accelerating Disturbances in Polar Coronal Holes* and *A Study of Quiet Sun Oscillations Using the Hinode, SoHO and TRACE Spacecrafts* in the "38th COSPAR Scientific Assembly", 18th – 25th July, 2010, Bremen, Germany and "7th Annual Meeting of AOGS", 5th – 9th July, 2010, Hyderabad.

R. Kariyappa presented a research paper on *Irradiance Variability* at the "International conference on Space Climate Meeting", Goa, from 16th - 21st January, 2011.

S. Krishna Prasad gave the following presentations *Coronal Line Width Variations & Complexities* in the "13th Young Astronomer's Meeting", 3rd – 5th September, 2010, PRL, Ahmedabad India; *Propagating Slow Magneto-Acoustic Waves in Coronal Loops as seen from TRACE & CDS* in the 38th COSPAR Scientific Assembly, 18th – 25th July, 2010, Bremen, Germany; *Propagating Slow Magneto-Acoustic Waves in Coronal Loops as seen from TRACE & CDS* in the "7th Annual Meeting of AOGS", 5th – 9th July, 2010, Hyderabad, India.

J. P. Lancelot with *A. K. Saxena* presented a paper on *Wavefront Sensor: Shack Hartmann Versus BC Based Shearing Interferometer for Adaptive Optics* at the International Conference on "Contemporary Trends in Optics and Optoelectronics" in Trivandrum during 17th – 19th January, 2011.

A. Surya with *S. K. Saha* presented a paper entitled, *Tomographic Speckle Imaging: Simulations with Multi-Aperture Telescopes*, 2011, at the International Conference on "Contemporary Trends in Optics and Opto-Electronics", held at Trivandrum during 17th – 19th January, 2011.

Poster Presentations in Meetings

S. Anathpindika presented a poster titled *Numerical simulations of shock-cloud interaction*, "National Astronomy Meeting", February 2011, Royal Astronomical Society, London.

S. P. Bagare presented following posters: (1) "IAU Symposium 273", 22nd - 26th August 2010, Ventura, USA, in session 1 on *Formation and Decay of Sunspots*; (2) Third Indo-China Workshop on "Solar Physics and 1st Asia-Pacific Solar Physics Meeting", 21st - 24th March, 2011, Bangalore and Chaired Session XI on "Solar Surface", *Active Regions and Magnetic Fields above them.* Presented two poster papers in session IV on *Observational Facilities and Instrumentation.*

B. C. Bhatt presented a poster titled *Venus Observations from 2-M HCT, IAO-Hanle (Ladakh)* co-authored by T. P. Prabhu & S. Limaye. at the "7th Annual Meeting of Asia Oceania Geo-sciences Society (AOGS)" organized at International Convention Center, Hyderabad, hosted by Indian Geophysical Union during 5th – 9th July, 2010.

C. Birdie, P. Prabahar & B. S. Mohan presented two posters titled *IIA Library – Beyond Books & Journals* and *Preserving Science at IIA Archives* during the "In-House Scientific meeting" held at IIA, 9th April, 2010.

G. R. Gupta presented a poster at the "Space Climate Symposium 4", 16th – 21st January, 2011, Goa, titled *On the nature of propagating MHD waves in*

polar coronal holes; "13th Young Astronomer's Meeting", 3rd – 5th September, 2010.

K. M. Hiremath presented two posters at the "4th Space Climate meeting", Goa, 16th – 21st January, 2011: (i) Manjunath Hegde, K. M. Hiremath and J. B. Gurman*, *Rotation Rates of the Coronal Holes and their Probable Origin*; Manjunath Hegde, K. M. Hiremath, J. B. Gurman and V. H. Doddamani *Dynamical and Thermal properties of the Coronal Holes.* Hiremath also presented posters at the 1st Asia-Pacific Meeting, 21 - 24 March, at IIA, Bengaluru, (i) *Dynamic and Magnetic Evolution of Sunspots from the Hinode data* by K. M. Hiremath; (ii) *Tilt Angle of the Bipolar Sunspots During Their Initial Appearance* by Lovely, M. R and K. M. Hiremath (iii) *Coronal Hole Oscillations Inferred from SDO/AIA Data* Manjunath Hegde and K. M. Hiremath.

J. Javaraiah presented poster papers at the following meetings: *Long-term Variations in the Evolutions of Sunspot Groups*, in the symposium "Space Climate 4", held during January 16th – 21st, 2011 in Goa, India; *Does the Sun's Surface Equatorial Rotation Rate Vary ?*, at the "3rd Indo - China Workshop on Solar Physics and 1st Asia Pacific Solar Physics Meeting", held at IIA during 21st - 24th March, 2011.

R. Kariyappa presented three posters titled *Interaction of Acoustic Waves and Intensity Oscillations with Smallscale Magnetic Features* by L. P. Chitta, R. Jain* & R. Kariyappa et al.; *First Results and Solar Irradiance Variability from PROBA2/LYRA* by R. Kariyappa et al.; *Coronal Rotation from XBPs Observed with Hinode/XRT* by R. Kariyappa, A. Agrawal* & L. P. Chitta, at the "3rd Indo - China Workshop on Solar Physics and 1st Asia Pacific Solar Physics Meeting", held at IIA during 21st - 24th March, 2011.

S. Krishna Prasad presented the following posters: *Propagating Intensity Disturbances in Polar Corona as seen from AIA/SDO*, in the "First Asia-Pacific Solar Physics meeting, March 21–24, 2011," Indian Institute of Astrophysics, Bangalore; *Complex Spectroscopic Variations as observed from Norikura Coronagraph* in the Astronomical Society of India meeting, 23rd – 25th February 2011, Raipur, India; *Study of Coronal Line Width and Intensity Variations using Norikura Coronograph* in the *Space Climate Symposium 4*, 16th – 21st January, 2011, Goa, India.

K. Nagaraju, K. E. Rangarajan, K. Sankarasubramanian & D. P. Choudhary** presented a poster paper titled, *Small Scale Chromospheric Velocity Structures*, at the "3rd Indo - China Workshop on Solar Physics and 1st Asia Pacific Solar Physics Meeting", held at IIA during 21st - 24th March, 2011.

Neeharika Sinha, Rajendra B. Singh, K. Sankarsubramanian, S. P. Bagare, K. E Rangarajan & S. S. Hasan* presented a poster paper entitled, *Spectro-Polarimetery with NLST: Evaluation of Seeing Induced Crosstalk Errors.* at the "3rd Indo - China Workshop on Solar Physics and 1st Asia Pacific Solar Physics Meeting", held at IIA during 21st - 24th March, 2011.

B. S. Nagabhushana & M. Srinivasa Rao presented a poster titled *Model for Solar Granules* "3rd Indo - China Workshop on Solar Physics and 1st Asia Pacific Solar Physics Meeting", held at IIA during 21st – 24th March, 2011.

*A. B. Sudhakara Reddy & S. Giridhar & D. L. Lambert** presented a poster titled *Comprehensive Abundance Studies of Four Open Clusters* at the 29th ASI meeting at Raipur during 23rd – 25th February, 2011.

*Sumangala Rao, S. Giridhar & D. L. Lambert** presented a poster titled *Elemental Abundances of RV Tau and Related Stars* at the 29th ASI meeting at Raipur during 23rd – 25th February, 2011.

Veeresh Singh participated in the International conference on "Accretion and Outflow in Black Hole Systems", held between 11th – 15th October, 2010, Kathmandu, Nepal and presented a poster titled *Measuring the Level of Nuclear Activity in Seyfert Galaxies and the Unification Scheme*; He also participated in the Conference on "Wide-band X-ray Astronomy: Frontiers in Timing and Spectroscopy", held between 13th – 16th January, 2011, IUCAA, Pune, India, presented a poster titled *Suzaku Broad-Band X-ray Spectroscopy of the Compton-thick Seyfert Galaxy NGC 5135.*

Chapter 2

Facilities

2.1 Photonics Laboratory

Adaptive optics experimentation

As part of the Adaptive Optics development programme, research on wavefront sensing using a Shack Hartmann wavefront sensor as well as the interferometric technique using Babinet Compensator is being done. The efficiency of the centroiding methods of the Shack Hartmann sensor, in the presence of photon noise and read noise has been improved. The methods were further improved with the introduction of simulated Kolmogorov atmospheric turbulence. An Adaptive Optics Laboratory at the Photonics division has been established in order to undertake current research programmes on Adaptive optics. As a first step an Adaptive Optics Kit from Thor Labs was acquired. Many experiments are being carried out for the formalization of new instrument development. A simple experiment has been developed to simulate Kolmogorov atmospheric turbulence in the laboratory. Two glass plates coated with commercial hairspray has been sandwiched and rotated to give the effect of Kolmogorov turbulence. This technique has been used elsewhere for testing 4m class telescope AO test bed. The same technique has been adopted here and tested with the AO kit from Thor labs. As a result Fried's parameter from the Zernike coefficients was computed. Some more experiments on closed loop are planned to be carried out using the AO kit in the coming months. The main focus is on developing an efficient wavefront sensing device. Parallel work is being pursued on refining the interferometric technique using Babinet compensators. Theoretical simulations of Kolmogorov turbulence have been simulated and its effect on the interferometric fringes have been studied. 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.

(A. K. Saxena, J. P. Lancelot, Narsireddy, Amita Mohanty & Suneeth)

Thin film research activities

Lyman α filter design: As part of the thin film research programme, the Lyman α bandpass filter has been designed, which has great astronomical applications for solar studies. Lyman α line has certain important applications in the study of chromospheric and coronal regions of the sun. Lyman α line is also important in the study of cosmological objects as well. A design has been formulated whereby six layers of aluminium as a metal and MgF2 as a dielectric spacer layer alternatively. The schematic of the optical design of the Lyman α filter is shown in (Figure 2.1). The transmission curve of the Lyman α filter as obtained from the 3 MDM design is shown in (Figure 2.2). The fabrication of the prototype as per the design has been initiated.

(A.K.Saxena & Mohammad Faisal Nawaz)

10.5 micron detector development

As part of the doctoral thesis work of Celine Joseph, an FIP student from Jyothi Nivas College, the development of the 10.5 micron detector was pursued. The design work has been completed and reported earlier. It consists of multilayer coatings, which has to be carried out by the Molecular Beam Epitaxy (MBE) method. Since, such a facility does not exist in-house; it was grown at the Cavendish laboratory, UK.

The voltage-current characteristics of the 10.5 micron Quantum Well Infrared Photo-Detector (QWIP) has been completed. The optical characterization will be carried out at SAC, Ahmedabad in a couple of month's time. The morphological study was

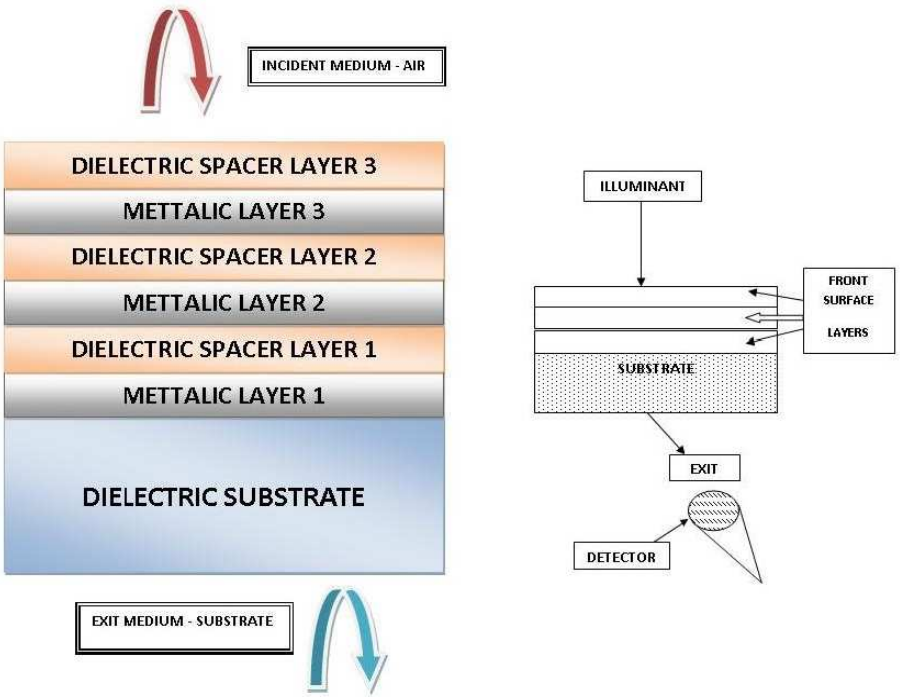


Figure 2.1: Schematic of the optical design of Lyman alpha filter.

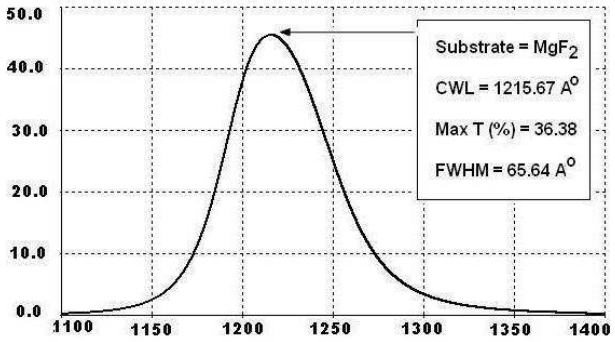


Figure 2.2: Transmission curve of the Lyman alpha filter.

done with the Scanning Electron Microscope and the theoretical dimension value is found to be in good agreement with the SEM values. Elemental analysis was done with the Energy Dispersive Spectrometer and its values are found to be comparable with the theoretical values. The packaging of the device was carried out at Centum Electronics, Bangalore. The packaged device is shown in the (Figure 2.3). A patent has been filed for the "Design and Development of 10.5 μm Quantum Well Infrared Photodetector (QWIP) for astronomical Applications".

(A. K. Saxena & Celine Joseph)*

Vacuum coating

The semi-automated and upgraded 1.5m vacuum coating plant ((Figure 2.4)) is completely operational. The trial coatings were carried out at a large number of small and large sized optical glasses. The quality of the coating was tested and found to be excellent. The performance of the coating plant has been greatly improved and the plant is in excellent condition (Figure 2.4).

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

Preparation for the first aluminization of the 2m HCT, Hanle

The general requirements for handling and coating of the primary and secondary mirror of 2m Himalayan Chandra Telescope (HCT) at the observatory's mirror coating facility, at Hanle, were undertaken. The optics of the telescope represents the major investment in project time & cost and also must be protected from damage during handling. Safe lifting equipment and procedures for maneuvering the mirror out of the telescope are mandatory. The complete aluminization operation includes, removal of mirror from the telescope, transportation and unloading, mirror preparation (stripping and cleaning),

Figure 2.3: QWIP packaged device

Figure 2.4: 1.6m vacuum coating plant.

Figure 2.5: Dummy mirror.

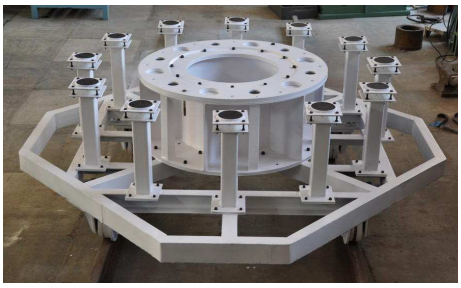


Figure 2.6: Mirror washing cart.

interface with the coating chamber, coating process, removal of the mirror from the chamber and putting back the mirror into the telescope. The dummy mirror has been designed and fabricated in-house efficiently to simulate at test condition (Figure 2.5). The washing cart (Figure 2.6) has also been designed and fabricated in house to facilitate the process of removing the old aluminium coating and cleaning and preparing the surface for loading in to the chamber. The mirror is lifted by engaging the lifting mechanism at the Cassegrain hole and placed onto the tilting fixture to check the fixture dimensions compatibility with the original mirror. The tilting fixture is shown below as (Figure 2.7). Tilting fixture is a circular holder for mirror, fabricated from stainless steel of SS304 grade having a diameter of 2100mm diameter. This circular holder fixture is supported on vertical bearings to facilitate rotation of the fixture, since the mirror has to be loaded into the chamber with the mirror rotated inverted for coating. The dummy mirror being loaded onto this mirror tilting fixture is shown in (Figure 2.8).

(A. K. Saxena & P. M. M. Kemkar)

VHRR Project

As a long standing collaboration between ISAC and IIA, beginning with INSAT - 2A, 2B, 2E, INSAT - 3A, KALPANA - 1 and INSAT - 3D, IIA was responsible for the optical polishing of sun shields that have been produced as per the specifications. ISAC also augmented the facilities at IIA for the development. The development of process on specimen level was completed and implemented on INSAT - 3D cooler sun shield after the evaluation of properties and process qualification by ISRO QA (Quality Assurance). Same process was implemented on single piece conical shield of LNA coolers of W2M spacecraft. As a follow up of INSAT 3D the optical polishing of the INSAT 3D R1 and R2 have been taken up.

Figure 2.7: Mirror tilting fixture.

Figure 2.8: Dummy mirror being loaded on to the tilting fixture.

(A. K. Saxena, M. G. Mohan, R. Ismail & P. Subramani)

Microcontroller based DC motor drive system for 12-inch Telescope

With the objective to design and develop a cost effective DC motor drive system for small telescopes, the following project was taken up. This drive system is intended to be an inexpensive counterpart to the imported telescope drives which have run into problem due to malfunctioning drive systems. This development is therefore being done in order to support and solve this problem.

It was possible to successfully control the direction and provide two additional speeds (in addition to tracking) to the motor, which can be used to acquire different objects in the sky. Further development of the drive system was continued. It included the addition of a feedback loop in order to keep the track of a star, irrespective of varying load conditions. Also, provision is made for manual tuning of the track speed with a potentiometer knob. This Drive System is operable with a Handset and can control both, RA and DEC motors. The motor being controlled in this project is a Pittman motor GM8224S021

Based on the command received from the user, the microcontroller sends appropriate TTL signals to the motor driver IC L293D.By properly interpreting these signals, the motor driver controls the 9V supply to the motor. Hence, the average voltage across the motor and thus the speed is controlled.An incremental encoder attached to this motor converts the actual speed into an electrical signal that is a TTL compatible square pulse, whose frequency varies with speed of rotation of the motor shaft. This signal is sent as feedback to the microcontroller, where it is compared against the commanded speed. Any deviation from the required speed is corrected by the controller, so as to make the error zero.

(A. K. Saxena, Kinjal & Roopa Maity)*

2.2 Electronics Laboratory

Multi-channel stellar polarimeter

The stellar photo-polarimeter, which has been under development, is nearing completion. A cross-mounted, calcite beam displacement prism is used to divide the incident light into two beams with mutually perpendicular planes of polarization. Two identical apertures placed at the focal plane of the telescope isolate the images, formed by these beams, and a rotating chopper alternately blocks one of the images allowing the other to be detected by the same photo-multiplier tube. The chopper can be rotated at almost 100 Hz. The chopper has been provided with four slots, two alternate ones for the ordinary image and two for the extra-ordinary image, making the effective chopping frequency almost 200 Hz. A super achromatic halfwave plate is used as the modulator in the polarimeter. The main advantages of the optical configuration chosen are: (i) The contribution of background sky polarization is completely eliminated from the data, thereby facilitating the observations of fainter stars during moonlit nights without compromising on the accuracy that is achievable during dark nights. This is possible because the

background sky is not modulated, it just appears as a constant term that can be removed from the data accurately. (ii) Since the same photo-multiplier tube is used to detect both the beams, the effect of any time-dependent variations in its sensitivity as a result of variations in the associated electronics, like HT supply, or otherwise, is negligible. (iii) The quasi-simultaneous detection of both the beams using a fast rotating chopper essentially eliminates the effects of variations in sky-transparency and reduces the errors due to atmospheric scintillation for bright stars significantly. (iv) The provisions for multi-spectral band observations can be easily incorporated in the design, making beam displacement prism based polarimeters to have an overall efficiency significantly higher than that of the usual Wollaston or Foster prism based polarimeters. In the present polarimeter simultaneous observations can be made in three spectral bands, which are isolated using two dichroic filters. If the accuracy of polarimetric measurements are photon-limited, the expected integration times to achieve a probable error of 0.05 per cent in polarization in UBVRI bands for a tenth magnitude A0 V star are around 17, 4, 4,5 and 6 minutes. The software for the control of the interface has been thoroughly checked and found to be quite satisfactory.

(A. V. Raveendran & G. Srinivasulu)

CCD Development work

The 4KX4K Mosaic Camera system for 1.3M DFM Telescope at VBO consists of a mosaic CCD dewar and CCD controller. The mosaic dewar was developed to mount the two CCDs (each 2KX4K, EEV 44-82 matrix, with 15X15μ pixels). Hardware testing of the CCD controller which comprises of digital signal processing board, analog signal processing board and two bias & clock boards is completed. The preamplifier board is made with two channels loaded for the two CCD chips. The buffer circuit is made for the output drain bias voltage and tested for the unity gain buffer. Software development is taking place. 2KX4K CCD camera system with cryotiger cooler has been built in which sensor is based on EEV 44-82 matrix of 2048 columns and 4096 rows, with 15X15μ pixels. Zif socket and pre-amplifier board testing completed. The camera system is being fine tuned for the optimization of noise performance.

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

White-light Active Region Monitor Telescope

Testing of control system of *WARM telescope* (White light Active Region Monitor Telescope) is completed. This system will be installed shortly at the Kodaikanal observatory for regular observations. Software control code is written in MINT-V5 platform.

(K. C. Thulasidharan)

2.3 Kodaikanal Observatory

Solar Tower Telescope

The new control systems at the telescope for the diurnal tracking and the microstep positioning for grating were put to regular use for observations, and the regular maintenance operations were carried out during the year. The indigenous dual beam polarimeter was used for specific observational programmes for detailed measurements of magnetic field configurations of selected active regions.

Synoptic observational facilities

The 15cm telescope was used for regular broad band imaging of the full disk, on photographic emulsion, as part of the plan to continue the over 100 year set of full disk observations with the same facility.

The twin telescope, which was built and put into operation in the previous years, was used to continue the Ca K and H-alpha synoptic observations. A new technique of image processing was introduced at the telescope. A sample of such processed image is illustrated in Figure 2.9.

One of the two 40cm DFM telescopes, which were procured specially for observations during the total solar eclipses in China, and in Easter Islands, was installed on a temporary platform at the Observatory. It is proposed to use this telescope at the Observatory to obtain G-band filtergrams as part of the synoptic observations. Necessary adapters were fabricated for the purpose. Trial observations were carried out with a G-band filter. The other 40cm DFM telescope is proposed to be installed at Merak in Ladakh. (Figure 2.10)

Two 15cm telescopes built by the Nanjing Astronomical Institute in China for dedicated narrow band H-alpha observations, arrived at the Observatory during the year. The telescopes will enable high cadence observations of the chromosphere us-

Figure 2.10: The newly installed 40cm DFM telescope at the Kodaikanal Observatory. Inset is the picture of the adaptor for G-band filter and the CCD camera.

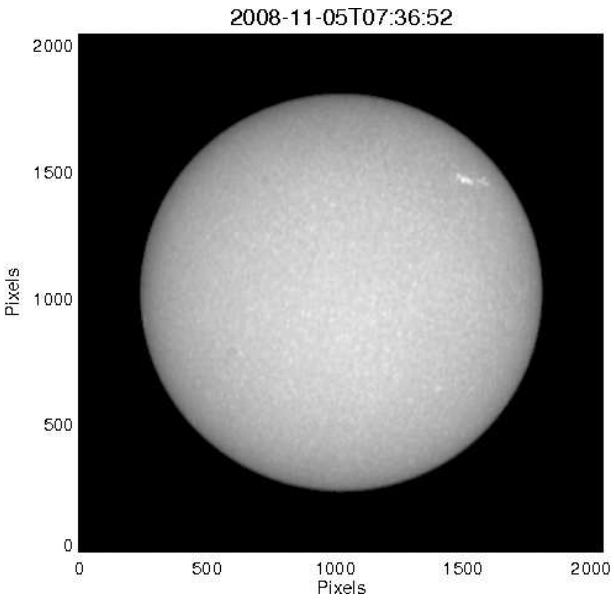


Figure 2.9: A Ca II K image taken from the Twin Telescope at Kodaikanal during November 2008 when the solar activity was very low. The image was processed using a technique developed in 2010.

ing CCD cameras. One of the telescopes is to be installed at the Kodaikanal Observatory and the other in Merak, to supplement the synoptic observations.

In addition to the research programmes of the Institute, the above facilities were used for project work under the guidance of the scientific staff at the Observatory, in partial fulfillment of M.Sc. and M.Phil. degrees of the Mother Teresa University (with which IIA has an MOU), and other Universities in the region. The Observatory carried on with the outreach program for general public with exhibits, models and a museum of old instruments. Thousands of visitors, including students from schools and colleges, visited the gallery.

Digitization programme

Digitization of the broad band photographic full disk images of the solar photosphere obtained at the Observatory for over 100 years, and of a comparable set of full disk images of the solar chromosphere, in the Ca K and H-alpha lines, was continued vigorously during the year. About 100,000 plates have already been digitized at full resolution. The raw data is being archived at the IIA data archival centre at Bangalore. Calibration related issues were resolved during the year and work is in progress to produce calibrated images for the entire data. The necessary software development for database management is also in the final stages of completion. It is proposed to make the data available to the scientific community for research work, after the completion of the above process.

(S. P. Bagare, Jagdev Singh, K. E. Rangarajan, D. Banerjee, K. Sundararaman, B. Ravindra, R. Selvendran, P. Kumaravel & Muthu Priyal)

Renovation of I & M building at Kodaikanal observatory

Based on the estimate given by the architects, a technical document giving the detailed plan for executing the renovation and remodeling of I& M building was put up in IIA web site. This building will be useful for conducting scientific meetings and schools. The renovation work is in progress.

(M. Ramaswamy, K. E. Rangarajan)

Sky conditions: Kodaikanal

		No. of observations			Seeing conditions*				
Year	Month	Ca K(TT)	WL(TT)	PHGM	5	4	3	2	1
2010	April	25	24	25	-	-	7	18	-
	May	27	28	22	-	-	3	19	-
	June	20	19	21	-	-	2	19	-
	July	7	7	09	-	-	2	6	1
	Aug	16	15	17	-	-	7	9	1
	Sep	13	11	15	-	1	2	11	1
	Oct	14	14	21	-	-	11	10	-
	Nov	12	13	14	-	-	8	5	1
	Dec	18	18	18	-	-	11	6	1
2011	Jan	27	27	29	-	6	16	6	1
	Feb	25	25	25	-	5	18	2	-
	Mar	31	31	31	-	14	12	5	-

CaK: CaK filtergrams taken by the twin telescope.
WL: Whitelight filtergrams observed by twin telescope.
PHGM: Photoheliograms observed through 6 inch telescope
*Seeing conditions (1-very poor, 2-poor, 3-fair, 4-good, 5-excellent)

2.4 Vainu Bappu Observatory

Reorganisation of some of the facilities at the observatory is underway. The building owned by the ISRO and used many years ago for satellite tracking, was handed over to IIA. After suitable repairs, the building will mainly be used for laboratories for instrument and detector development and to house the central data server for the observatory. This will free the VBT building from serving these roles and will considerably reduce the heat generation within the VBT building.

Procurement of a new data server with 10 terabytes of storage was initiated. This system will be for archiving the data from all telescopes as well as for eventually providing an on-line archive. Upgradation of personal computers at the telescope domes (1m, 2.3m) and laboratories was also taken up.

The Vainu Bappu Telescope completed 25 years since it was dedicated by the late Prime Minister Rajiv Gandhi on 6th Jan 1986. A meeting to commemorate the event is planned during August 2011. For this event, the VBT itself was repainted by early 2010. The painting of the 1m and VBT buildings and domes is planned before the meeting.

The 1.3m Telescope Project at Vainu Bappu Observatory

The mechanical structure of the telescope as well as the hydrostatic bearing systems and telescope drive systems were completed and tested at the facility of the vendor, M/s DFM Engineering. The telescope is in a semi-assembled state and is awaiting completion of tests of the optics. The bench tests of the optics is planned in May 2011, after which the telescope will be assembled with optics.(Figure 2.12)

The detailed design of the steel enclosure and dome for telescope was completed and the tender process is expected to be initiated by May 2011. The building of the telescope pier and the foundation of the outer structure commenced with excavation at site in August 2010, and has progressed considerably. The pier has been designed with special grade of concrete mix consistent with the stiffness requirements. The construction process entails frequent tests of the strength of sample concrete blocks. The telescope pier and building will be unique in its design, when completed. The Figure 2.11 and Figure 2.13 show various stages of the construction.

(A. K. Pati)

Figure 2.11: Pier upto a height of about 4.5 metres surrounded by the outer structure upto ground floor (February 2011).

Status of 30 inch Telescope control system, VBO

The 30 inch telescope control software and hardware were tested for its functionality during the last observing season. A more elaborate testing was undertaken this year for positioning, tracking and guiding performance. Based on the preliminary performance evaluation of last year the following modifications in mechanical, electronics and control software were effected.

The pre-load at RA end was reduced from 50 kgs to about 30 kgs. This reduced the normal operating current by about 1 amp. A provision for movable counter weight was provided at DEC end. The software was modified for tracking improvement and the Positioning algorithm was also improved. The software for handset controls which provides options of SET, GUIDE and FINEGUIDE was incorporated. A provision for display of secondary focus position using digital dial gauge was provided.

With the above changes, the position data for nearly 250 stars was collected for telescope mount modeling purposes. Efforts are on to use this data in building a model and deriving constants using the software code developed by A. Raveendran. But based on the preliminary data the telescope can be positioned to better than 2.5 arcmin automatically in programmed move mode and can be positioned to any accuracy with the handset controls.

It is also noticed that on most occasions the object is positioned within 1.5 arcmin and sometimes within 15 arcsec. So the object is always within the frame

Figure 2.12: The assembled mount of the 1.3m telescope at the vendor facility

Figure 2.13: Casting of base of the Pier as in August – September 2010

of CCD detector which is 8 arcmin^2.(1k*1k)

Regarding the tracking performance, based on the preliminary tests the telescope can remain unguided possibly up to 1 min and near zenith it can remain unguided for upto 7 min. Test images taken with the telescope are shown in Figure 2.14).

(A. V. Ananth, V. Arumugam, P.Anbazhagan, A.Ramachandran, K. Ravi, V. Rao)

Earthing using artificial methods

The improvement of earthing using artificial methods was introduced in VBO, Kavalur campus. In the artificial method, the chemicals used is electrolyte instead of salt & charcoal. The earth resistance value improved due to this method but its value should reach less than 3 Ohm. Work is on to achieve this.

(R. Vellai Selvi)

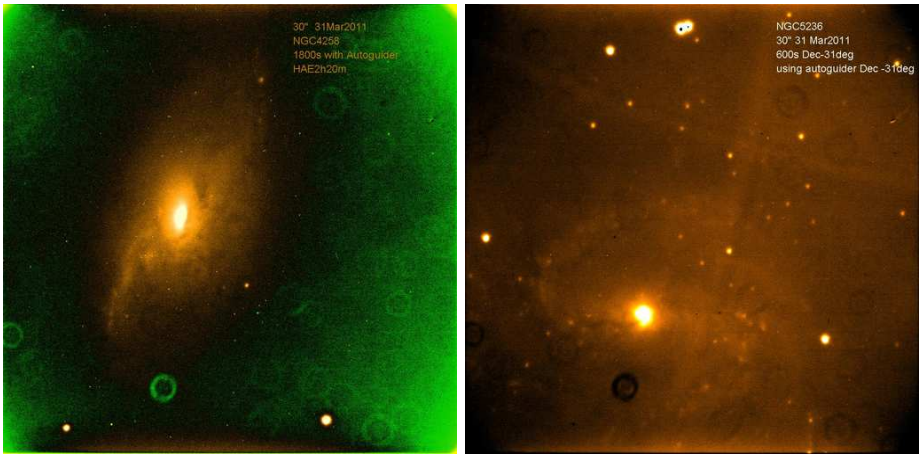


Figure 2.14: Images acquired from the 30 inch telescope.

Sky Conditions

Month	Spectroscopic Hours	Photometric Hours
April 2010	106	0
May	126	7
June	29	0
July	17	0
August	34	3
September	39	2
October	29	0
November	23	0
December	61	14
January 2011	244	81
February	166	77
March	269	89
Total	1143	273

2.5 Indian Astronomical Observatory

Himalayan Chandra Telescope (HCT)

HCT completed ten years since its installation in August 2000, and nearly eight years since its remote utilization from CREST campus with all the first generation instruments available to astronomers through competitive time allocation. The total number of research papers published during this period was 85, apart from papers presented at conferences.

Figure 2.15: HCT completed 10 years since its installation on Digpa Rasta Ri on 26th September, 2010.

HCT Time Allocation Committee

New TAC was formed, effective from 2010 April. Members: G. C. Anupama (Chair, IIA), B. E. Reddy (IIA), D. K. Ojha (TIFR), A. N. Ramaprakash (IUCAA), S. Seetha (ISAC).

Fifteen proposals were received for Cycle 22 (2010 May-August), 26 proposals received for cycle 23 (2010 September - December) and 21 proposals received for cycle 24 (2011 January - April). Telescope is oversubscribed by a factor 1.5 on an average, while the dark moon period is over-subscribed by a factor 2.5-3. HCT proposals cover a wide range of scientific problems, from the observations of nearby solar system objects to distant quasars.

(G.C. Anupama)

Size distributions of fine and ultra fine particles in the free troposphere: Observations from the High Altitude Station Hanle, in the Himalayas

Regular measurements of aerosol number size distributions were carried out at a mountain top observatory located in the trans-Himalayas during August to November 2009. The total number of concentration values ranged from 50 to 8000 cm^{-3} and the mean value was less compared to other measurements from Indian Himalayan sites, which are located at comparatively lower altitudes. Simultaneous examination of the number concentration and geometric mean diameter values revealed that the formation of the new particles from the precursor gases (transported from the valley regions) is highly probable during the forenoon hours of the day. Also, a drift in the time of the maximum concentration has been observed, which is inferred as a result of decreasing sunlight as the days approach towards the winter season. The number size distributions show a consistent accumulation mode with the mode diameter ranging in between 115 to 150 nm. With the help of a special classifier, it was able to capture the nucleation mode, whose diameter is found to be 16 nm. Finally, an attempt has been made to classify the size distributions in accordance with airmass trajectory clusters, which revealed that the advection from the west Asian regions is predominant during the study period, which broadens the accumulation mode and increases the total number concentrations. Only during August, the number concentrations are highest whenever the airmass is from the Indian origin and the ratio of the Aitken to Accumulation mode concentration indicates the aerosol particles existing over the site are quite aged.

*(*K. Krishnamoorthy et al. including T. P. Prabhu, S. P. Bagare, B. C. Bhatt, N. Shantikumar Singh & V. K. Gaur)*

HCT maintenance

The preventive maintenance activities of HCT were carried out on monthly basis, around full moon when

there is no demand for observational programmes. Various calibrations and checks were done periodically to keep the performance of the telescope at its optimum level. The following items are checked each month and attention is provided as required:

(1) Azimuth motor alignment. (2) Secondary actuator servicing, cleaning and routine checks: This includes replacement of the actuator micrometers/ruby switches when required. (3) Primary warping harness tuning and support system routine checks: this includes observation through Shack-Hartman instrument from CREST and follow up at Hanle for on fine tuning. (4) Azimuth drive disk cleaning. (5) Telescope axle bearing checks and lubrication. (6) Azimuth and rotator encoder tape cleaning. (7) Optics cleaning with distilled water. (8) Mirror cover mechanism checks and servicing. (9) Optical alignment and re-collimation. (10) Pointing Model. (11) Lead screw calibration.

The dome also requires periodic checks and following preventive maintenance activities were carried out:

(1) Servicing Wheel assemblies and lubrication of bushes. (2) Inspection and preventive maintenance of guide wheel assemblies. (3) Shutter chain sprocket maintenance and routine checks. (4) Dome rail check and lubrication.

During September, 2010 annual maintenance of the telescope was carried out. Engineers from IAO, IIA, M/S ESOT, Tucson, and Scientists from IIA participated in this activity. A trial run of preparation for removing the primary mirror before aluminization was also undertaken during this period. The warping harness of the primary mirror support system was fully released and then tuned again to get back the original image quality.

(1) Additional Rudder assembly was installed at the south east azimuth motor to contain the run out. (2) Tuning of the azimuth motor run out and checks of motor run out on elevation and azimuth axis. (3) Check of carbon brush on azimuth and elevation motor. (4) Checks of Limits switches. (5) Encoder tape cleaning of azimuth and rotator axes. (6) Azimuth drive disc cleaning and inspection. (7) Axle bearing checks and lubrication. Elevation bearing checks. (8) Secondary actuator checks / inspection of the mechanism. (9) Optical checks, centering and re-collimation. (10) Primary mirror support check inspection and advice. (11) Pointing model. (12) Leadscrew calibration.

During October 2010, because of the deorbitting of the existing communication satellite and allotment of bandwidth in another satellite there used to be problems in remote operation of the telescope from CREST for a few hours every night. A launch failure subsequently has made it necessary to squeeze in C and Extended C band requirements very tightly. With support from ISRO the down time of the link was brought to a minimum. The engineers and support staff at Hanle have been taking observations for the proposers whenever the link goes down.

(D. K. Sahu, Tsewang Dorjai, Dorje Angchuk, Tashi Thsering & Sonam Jorphail)

TIFR IR Spectrograph-Camera (TIRSPEC)

The Infrared Astronomy Group of the Department of Astronomy & Astrophysics, TIFR, Mumbai, is developing a near-infrared (NIR) spectrometer and imager (TIRSPEC) based on 1024 x 1024 HgCdTe focal plane array (HAWAII-I 1K PACE detector; spectral response 1 2.5 micron) optimised for the 2-meter Himalayan Chandra Telescope at Hanle. The NIR spectrometer with imaging capabilities is being developed by Mauna Kea Infrared, LLC, Hawaii, USA in collaboration with the Infrared Astronomy group in TIFR and technical inputs from IIA. The NIR spectrometer has a resolving power of 1500 in J, H and K bands. TIRSPEC is in an advanced stage of fabrication. It will be installed, commissioned jointly by TIFR and IIA during autumn of 2011, and operated jointly as a general facility on HCT following the science verification phase.

TIRSPEC will be extremely sensitive to low temperature stellar photospheres and objects surrounded by warm dust envelopes or embedded in dust or molecular clouds. It is therefore particularly suited for the study of low and very low mass stellar populations, strong mass-losing stars on the asymptotic giant branch, and young stellar objects still in their protostellar envelopes. It will also be useful in the study of active galactic nuclei, supernovae and afterglows of gamma-ray burst sources.

(D. K. Ojha & T. P. Prabhu)*

Antipodal Transient Observatory

M/s EOST engineers investigated the alignment of the elevation encoder on the 50m ATO and also the damaged azimuth bearing disc. Subsequently the pointing procedure was undertaken afresh and the telescope performance improved considerably.

(Dorje Angchuk, Tsewang Dorjai & T. P. Prabhu)

HIGRO Collaboration

The HiGRO (Himalayan Gamma Ray Observatory) collaboration consists of IIA, TIFR (Mumbai), BARC (Mumbai) and SINP (Kolkata). The facilties include the High Altitude Gamma Ray (HAGAR) experiment which was operational in 2008, and Major Atmospheric Cerenkov Experiment (MACE) under advanced stage of fabrication. The telescope foundation and control room were constructed at the site during the current year, while the telescope is under fabrication at ECIL, Hyderabad and their subcontractors.

HAGAR maintenance

Maintenance work carried (1)Cleaning of the Mirror with distilled water. (2)Replacement and alignment of the Potentiometer pinion. (3)Inspection of the azimuth and elevation axis drive mechanism and lubrication. (4)Tube cover mechanism installation and trial operation. Though we have installed the mirror cover mechanism and carried operation of single flap. There need some improvement. At present the mechanism is installed but not in operation. (5)Eye piece /ST4 camera adapter mount bracket fabrication. (6)Other minor maintenance work of Telescope sheet works.

(Tsewang Dorjai)

Analysis of FADC data

HAGAR has parallel DAQ consisting of Flash ADC or waveform digitizers of commercial ACQIRIS make. This system continuously digitizes eight analog channels at 1G samples per second and records data of 1000 samples around trigger. Using this system, addition of PMT pulses forming telescope pulse was examined. Slight delays between PMT pulses arising as a cumulative effect of differences in PMT transit times, differences in coaxial cable delays, differences from delays caused by various electronics modules, were estimated using FADC data and compared with the measurements of these delays.
(S. Kale & V. R. Chitnis)

Simulations for HAGAR

Simulations play very important role in experiments like HAGAR. In absence of direct calibration with sources of known energies, performance of these experiments can be understood only through detailed simulations. During this year, large samples of showers initiated by gamma rays and various species of cosmic rays including protons, alpha particles and electrons were simulated for vertical incidence as well as for various incidence angles. Taking into account inputs from experimental setup, simulation parameters were updated. Performance parameters were estimated for vertical as well as inclined showers. Energy threshold was found to increase from 205 GeV at vertical to about 510 GeV for inclination angle of 45 deg. Corresponding increase in collection are was estimated to be from $3.2*10^4$ to $1*10^5$ m^2. Detailed comparison between simulations and data was initiated. Distribution of space angles, i.e the angle between direction of reconstructed shower axis using plane front approximation and pointing direction, was found to be consistent with the observed distribution. Also simulated pulses of night sky background matched well with the FADC traces. Distributions of shape parameters for observed Cherenkov pulses as given by FADC were found to be consistent with the distributions from simulations.

(V. R. Chitnis, S. Kale, A. Shukla & others)

Sky Conditions, Indian Astronomical Observatory, Hanle, Ladakh.

A. Night hours

Year	Month	Photometric (night hrs)	Spectroscopic (night hrs)	Total (night hrs)
2010	April	84	138	240
	May	97	127	217
	June	107	126	210
	July	65	84	217
	August	38	50	248
	September	122	161	270
	October	243	265	310
	November	169	281	330
	December	206	254	341
2011	January	182	226	321
	February	81	112	280
	March	160	193	341
	Total	1654	2017	3283

Sky Conditions, Indian Astronomical Observatory, Hanle, Ladakh.

B. No. of Nights

Year	Month	Photometric nights	Spectroscopic nights	Total
2010	April	12	20	30
	May	16	20	31
	June	16	18	30
	July	11	12	31
	August	5	7	31
	September	17	19	30
	October	26	27	31
	November	26	27	30
	December	20	25	31
2011	January	15	22	31
	February	11	13	28
	March	20	23	31
	Total	200	235	365

2.6 Gauribidanur Radio Observatory

Gauribidanur RadioiHeliograph (GRH)

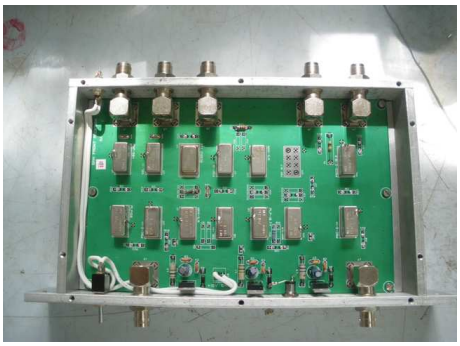


Figure 2.16: The front end analog receiver (farbricated in house at Gauribidanur)

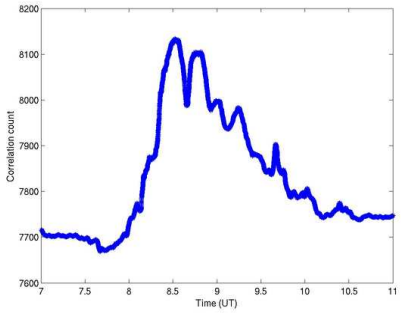


Figure 2.17: Time profile of the radio signature of the solar flare observed with one of the antenna groups on August 1, 2010

The following activities related to the expansion of the radioheliograph at the Gauribidanur observatory are presently underway:

(1) In house fabrication of 64 channel analog front end receiver (corresponding to the 64 antenna groups in the expanded array); (2) In house fabrication of a 4096 channel digital back end receiver for correlating the signal for each antenna group in the array with every other group. (3) Characterization of each one of the 64 antenna groups in the array with a prototype receiver. (4) In house fabrication of 150 delay shifter units for steering the 'beam' of the array in right ascension and declination. (5) Trial observations with the existing 1024 channel digital back-end receiver.

(R. Ramesh)

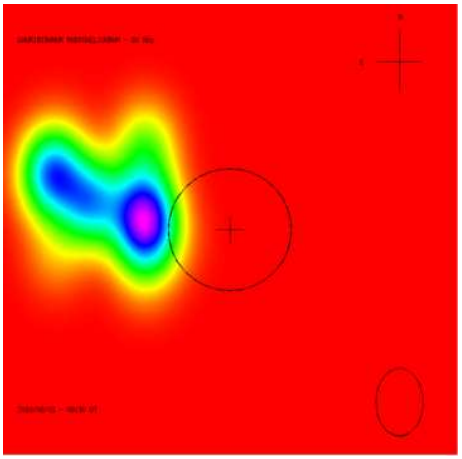


Figure 2.18: The corresponding two-dimensional radioheliogram showing the associated CME.

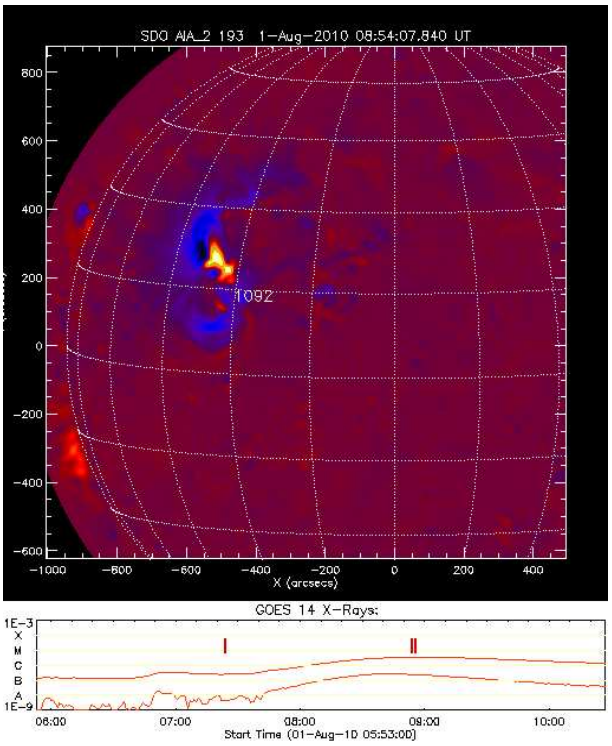


Figure 2.19: The flare as observed with the extreme ultraviolet imaging telescope on board the Solar Dynamical Observatory (SDO), and the soft X-ray emission from the whole Sun during the flare period obtained with the X-ray sensor onboard GOES 14.

2.7 The Library

During the year the number of items in the physical collections increased considerably, however the growth of the electronic resources also recorded high. The library focused on improved communication about the services offered, especially the access to e-resources.

The library has acquired multi-site licenses of most of the high-priority journals for use by the faculty and students of all the campuses and field stations of IIA. The access to e-books has been prioritized as it facilitates the use in all the campuses, equally and simultaneously.

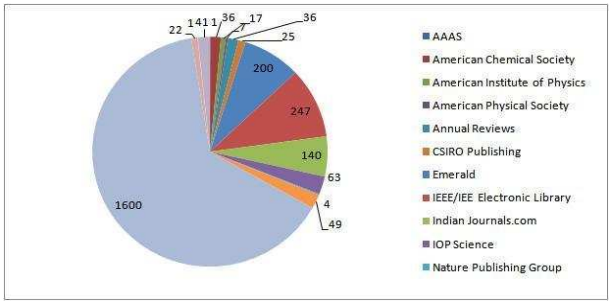


Figure 2.20: e-Journals.

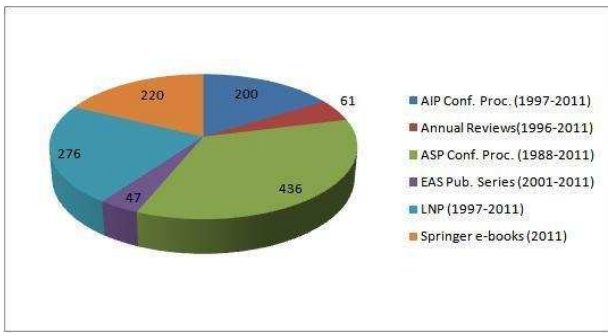


Figure 2.21: e-Books.

The digital form of the e-book and its chapters can be read using computers and through stand alone e-book readers. During the year, IIA library has subscribed to the following e-books from different publishers on perpetual access model.

(1)AIP Conference Proceedings (1997-2011)- 200 titles;
(2) EAS Publications Series (2001-2011)- 47 titles;
(3) Springer e-books (2011)- 220 titles.

IIA library is also exploring the possibility of acquiring e-book readers which can be borrowed by the users.

The library trainee programme is continued and two trainees are trained to carry out all the library services.

Archives: The collection in the Archives continues to grow with more contents added from the Institute's administrative and technical files which have old correspondences and reports on the scientific work done in earlier days.

Event related exhibits are organized using the material from the Archives. On the occasion of founder's day on 10th August 2010, IIA library organized a photographic exhibition, covering Prof. M. K. V. Bappu's profile and research when he was the Director of IIA (1960 – 1982). Library brought out a flyer titled *Remembering Bappu*, with a glimpse of exhibits displayed in the exhibition. Library also hosted a poster exhibit on the occasion of the centenary conference of Prof. S Chandrasekhar held at IIA in December 2010. Another flyer was brought out with the glimpses of items displayed in the exhibit with a title *Recapturing Chandra @ iia*. Both displays featured publications, photographs, correspondence and hand-written manuscripts of respective scientists.

In support of World Book & Copyright Day, on 23rd April, 2010 library designed and displayed the World Book & Copyright poster in IIA Bangalore Campus.

In support of Open Access Movement and Open Access Week celebrated all over the world during 18th – 24th October, 2010, library designed and displayed the Open Access poster in IIA, Bangalore Campus to create awareness about the Open Access among the faculty and students.

Compact Storage: A compact storage consisting of 8 units of closed racks with a locking facility was installed in the library main hall. The storage is useful in mitigating the space problem for shelving of books and journals which keeps growing.

Open Access Repository: Open Access (OA) of IIA is maintained by the library, which includes the research publications, both current and historical, published by IIA faculty and students. Currently IIA's open access repository is ranked 211 in the list of top 1200 institutional repositories covered worldwide as of January 2011 and contains 5221 records.

Recently OA repository included three new communities (a) Technical Reports - to include the reports and papers on technical works and project sum-

maries carried out at IIA. (b) Posters, Brochures, Fliers and Bookmarks - All the unpublished posters, brochures flyers etc. brought out on different occasions at IIA are uploaded here. (c) Video Presentation - Multimedia presentations projecting IIA's profile and scientists, interviews and outreach programmes are uploaded under this community.

IIA library staff support the faculty in publishing, disseminating and preserving their research by uploading and maintaining the OA Repository.

(Librarian)

2.8 Computational Facilities

The computer facilities at IIA has always been individual based, where most of the academic members of the Institute use their own workstations for complete computing needs. In the recent times, there has been a rising demand for larger memory, higher processing and storage that are beyond the limits of conventional workstations. The new data centre is expected to satisfy this rising demand for computing power and storage.

A new-20 node high performance computing cluster with a peak performance of around 5.8 TFlops is presently being configured in the data centre. Based on Xeon X5675 processors, this new HPC cluster supports 24 logical processing cores and 96 GB DDR3 memory per node. Interconnect is through Infiniband QDR (40 Gb/s). A GPU computing server based on nVidia Fermi C2070 GPU cards, with a peak floating point performance of 2.6 TFlops is already operational. Apart from these, a new data processing server with dual AMD Opteron 6176SE 12-core processor and 32GB DDR3 memory is also available for memory intensive data processing requirements. On the storage front, a new 12 TB IP-SAN disk server is now operational and will be upgraded to 36 TB in the near future. The 20-node cluster has an associated storage module of 48 TB raw disk space. These are new additions, alongside the existing 10TB disk server.

IIA has always been a source of astronomical data. The new data centre will host data from Institute's observatories. Starting with the 100+ years of digitized solar images from Kodaikanal Solar Observatory to the optical telescopes and upcoming space astronomy missions, all data will be made available through the data centre. Work is in progress to prepare a common interface to provide access to these data.

Internet bandwidth has been upgraded recently to 25 Mbps. A secondary internet link from National Knowledge Network (NKN) is functional now and it offers a total bandwidth of 1 Gbps, shared by various research institutes in Bangalore. Institute's LAN is being upgraded to a new 1 Gbps high speed network infrastructure. Field stations at Gauribidanur, CREST and Kodaikanal are now part of the main campus LAN via MPLS network.

(Dipankar Banerjee)

2.9 Upgrade of Infrastructure

Figure 2.22: The Advanced lightning protector.

Two UPS systems of 120 KVA capacity were added to take care of requirement of the desktop computers and the data centre. A dedicated 120 KVA feeder line was laid and commissioned between the power house and the computer data centre. An advanced version of lightning protection systems were installed. At the Bhaskara guest house, a 150 KVA stabilizer was commissioned.

(G. Srinivasalu)

2.10 Upcoming Facilities

2.10.1 ADITYA 1

ADITYA-1 is a project to launch a 20-cm aperture coronagraph to obtain the images of the solar corona

in the two of the brightest emission lines namely green and red in the visible part of the coronal spectrum. The green and red emission lines at 530.3 nm and 637.4 nm represent plasma at the temperatures of about 2 and 1 million K. It is proposed to take images of the solar corona at a frequency of about 3 Hz to study the existence of waves due to intensity variations. It is also planned to study the topology of magnetic fields in the solar corona and its effect on the triggering and acceleration of CMEs. The high energy charged particles and high-speed solar wind creates disturbances in the space weather and interact with the earth's atmosphere. The prediction of space weather is very important for space programmes and a number of advanced electric, electronic and similar facilities on the earth.

The ADITYA project was finally approved by the Department of Space, Government of India on 11th December, 2009 after a number of reviews of the project by ADCOS and committees constituted by ADCOS. On 18th May, 2010 the Chairman, ISRO approved the constitution of the project team along with the responsibilities of the members of the team. The chairman, Indian Institute of Astrophysics constituted a Project Management Board (PMB) to monitor the progress of the project and make required suggestions. Subsequently MOU has been signed between ISAC and IIA to develop and deliver the payload (coronagraph) for ADITYA-1 in March 2011.

The team from IIA, USO, ISAC and LEOS had a large number of meetings to finalize and optimize the optical design of the coronagraph. The detailed specification of all the mirrors, lenses, filters and other components have been worked out. A committee has been constituted to have a BDR review of the detailed specifications. The test and calibration procedures for the optical component as well as for the system have been worked out. The mounting scheme for the optical components has also been proposed. It is proposed that the micro-roughness of the primary mirror should be of the order of 0.1 nm to keep the scattered light component at the low level required for the coronal studies.

The other major component of the project is development of the detectors. All the available CCD chips have been explored to find the suitability of the detector to meet our requirements of low noise, high efficiency and the large dynamic range. Chips were short-listed from Semiconductor Laboratory, Chandigarh (SCL); C-MOS from Fairchild and E2V chips (operation in frame transfer mode). Several experiments with C-MOS and SCL chips have been made to study the linearity, efficiency, read out and dark noise, and other parameters of the chips at SAC Ahmedabad. It may take some more time to conclude the choice of the chip.

The structure, thermal and mounting designs of the payload are being worked out by the team from IIA and ISAC. Some studies have been made to achieve the required pointing accuracy of the satellite and control the jitter in the satellite.

(Jagdev Singh)

2.10.2 HCT Echelle Spectrograph

It is proposed to build a high resolution Echelle spectrometer for the 2m Himalayan Chandra Telescope (HCT) at Indian Astronomical Observatory (IAO) Hanle, to meet the observational requirements of many front line areas in astronomy. This instrument, is based upon a modern design using white pupil concept where a dual mode collimator forms white light image of the grating to be re-imaged by the camera with desired beam size. This instrument also incorporates additional features like image-slicer which would give high light efficiency. The instrument would support two resolution modes. In sliced mode, a resolution of R$\sim$ 60,000 will be obtained while unsliced mode is available for relatively lower resolution mode R $\sim$ 30,000 adequate for certain programmes and will enable spectroscopy of relatively fainter objects. it would provide continuous spectral coverage (350 nm – 1000 nm) in a single CCD frame, minimized vignetting and scattered light and very high mechanical stability. It would also provide a user friendly interface and very professional star acquisition and guiding facility without manual intervention.

A concept design for the instrument has already been prepared. It is envisaged as a technical collaboration between IIA and Industrial Research Limited, New Zealand. A work agreement has been developed and it is expected that the project will be completed in 2.5 to 3 years.

It would provide impetus to several front-line scientific programmes such as asteroseismology, detection of extra-solar objects, abundances of elements and their isotopic ratios, studies of extended envelopes around the evolved stars, Tomography of accretion disks and stellar winds, studies of spotted stars etc.

(S. Giridhar)

Figure 2.23: Engineering Model (EM)-UVIT Payload in class 1000 area at CREST, IIA. In EM-UVIT is shown: NUV/VIS (black colour), telescope is identical to Flight Model (FM), and the other telescope is a mass equivalent of FUV telescope.

2.10.3 Ultra-Violet Imaging Telescope (UVIT)

UVIT is one of the five science payloads on ASTROSAT: there are four X-ray telescopes, which observe in soft/hard X-rays, and UVIT observes in ultraviolet and visible bands. Three of the X-ray telescopes and UVIT can observe an object simultaneously. UVIT observes simultaneously in Far-UV (1300–1800Å), Near-UV (2000–3000Å), and VIS (3200-5500Å). Images are made, with an angular resolution of $\sim$ 1.8 arcsec in a field of $\sim$28 arcmin. In addition to a selection of filters for each of the three channels, low resolution ($\sim$100) slitless spectroscopy is available for Far-UV and Near-UV channels. ASTROSAT aims to observe simultaneously in X-ray, UV and visible. UVIT could be used to study 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.

Present Status: Engineering model of the payload has gone through vibration tests at ISAC as per the requirements of ISRO. These tests were considered very crucial, as the payload is large in size (total length of $\sim$ 3m). Results of the tests have shown that the flight model payload can be assembled with some changes in design of the structure. All the structural components of the flight model, the filters, and the detector systems are in hand. The mirrors are expected to be delivered by LEOS by June 2011, and the filter – wheels too are expected to be obtained from IISU (ISRO) on similar timescale.

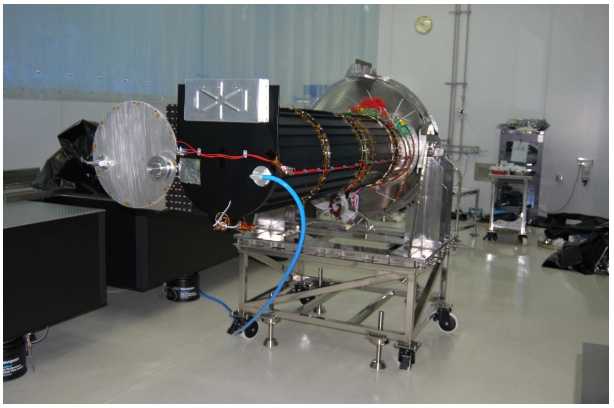


Figure 2.24: Front part of NVU/VIS telescope is shown with door. The door minimises contamination and it is opened in the orbit.

The structural parts have to undergo fixing of thermal components (heaters etc.) and after this is done assembly of the flight model can start in June 2011. The assembly and testing of the flight model would take about 5 months at CREST. After this, the payload would be transferred to ISAC for environmental tests and integration with the spacecraft. The launch of ASTROSAT should take place in July 2012.

(UVIT team)

2.11 New Initiatives

2.11.1 National Large Solar Telescope (NLST)

Ground based optical solar astronomy is presently at an exciting phase of development. Till recently, only 1m class solar telescopes were in existence throughout the world. From 2009 onwards 1.5m class, telescopes have come into existence. The next step would be a 2-m class facility. The Adaptive Optics technology crucial to taking forward the large telescopes to the diffraction limited performance has come of age for observations of the Sun. Efficient heat rejection and cooling systems are being designed recently. Such major initiatives are necessitated by the quest for advancing our knowledge of the Sun and understanding its impact on the terrestrial environment.

IIA has proposed a 2-m class, state-of-the-art National Large Solar Telescope (NLST) that will permit Indian scientists to carry out cutting edge research aimed at understanding the fundamental processes taking place on the Sun. Its innovative design and

backend instruments will enable observations with an unprecedented high spatial resolution that will provide crucial information on the nature of magnetic fields in the solar atmosphere. A novel feature of this instrument is that it will also be used for night-time astronomy.

The NLST Observatory will be located on top of a specially designed tower with an open design to allow air flushing. In addition, the primary mirror will have an active temperature control system, to ensure its thermal balance with the environment. The optical design of NLST will provide a four times higher throughput compared to the existing 1.5-m class telescopes.

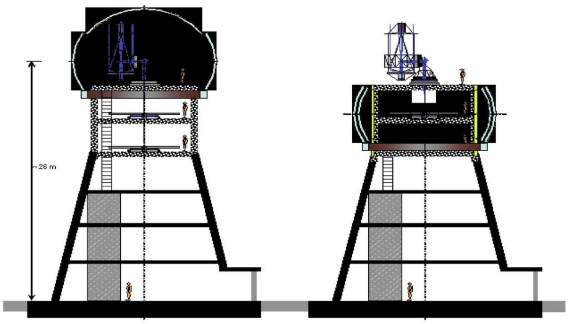


Figure 2.25: NLST has an open design to facilitate effective flushing of the heat due to the natural air flow. The telescope will be located atop a tower at an altitude of about 26 m. The focal plane instruments will be placed below as shown in the figure, which shows a schematic layout of the tower with the telescope dome (a) close, and (b) fully retracted.

NLST is expected to be the largest solar telescope in the world for several years i.e. till 2020, when the next generation of 4-m class telescopes would come into operation. Furthermore, this telescope fills the longitude gap between Japan and Europe.

A Detailed Project Report was brought out in February 2011 which provides details on: (a) The need for a large solar telescope; (b) the scientific objectives; (c) Site characterization programme; (d) Strategy for implementation of the project; (e) Human resource development; (f) Budget; and (g) Technical aspects that includes a detailed concept design. The project is awaiting formal sanction.

(S. S. Hasan, K. E. Rangarajan & the NLST Team)

Site characterization programme for NLST

The programme completed five years of observations at the field stations, Hanle, Merak, and Devasthal. The data obtained so far are sufficient to draw reasonable and meaningful conclusions on the day time seeing conditions at the three sites. The project lab and office at Bangalore carried out the monitoring of the observing schedules, the day to day functioning of the programme, the online downloading of data, and the development and use of software for analysis and interpretative study. The regular maintenance of instruments was carried out at the field stations and repairs, where necessary, were undertaken at Bangalore. Station-wise details of work and development during the year are as follows:

Hanle: A total of 26 months of observations with the NSO-SDIMM & SHABAR (18 months) and IIA-SDIMM (8 months) was completed. High cadence observations with the Campbell Automatic Weather Station (AWS) continued during the year to complete a five year spell of collecting met data at the site. The Prede sky radiometer, which completed successful continuous observations for over 3 years, was shifted to Merak in December 2010. The micro thermal observations were discontinued at Hanle since data had already been procured for over two years. It is proposed to continue with only the AWS observations during the coming year.

Merak: The NSO-SDIMM and SHABAR observations were carried out at Merak for about 8 months before the system developed technical problems in June 2009. However, seeing observations continued with the IIA-SDIMM for about 22 months. Thus a total of 30 months of continuous seeing observations have been completed so far at Merak. Further, observations with the micro thermal device, the all-sky camera, and the high cadence AWS continued during the year. The Prede sky radiometer was installed at Merak in December 2010 and regular observations started. All these observations will continue during the year ahead. Figure 2.26

Devasthal: The IIA-SDIMM completed 15 months of near-continuous observations at Devasthal. The AWS, the all-sky camera, and the micro thermal observations also continued during the year. It is proposed to continue these observations in the coming year, except during the months July to September, when monsoon is severe in the region. Figure 2.27

NLST Lab and office at IIA, Bangalore: Monitoring of the entire site programme, including the regular observations, the online downloading of data, procurement of bulk data, development of software and

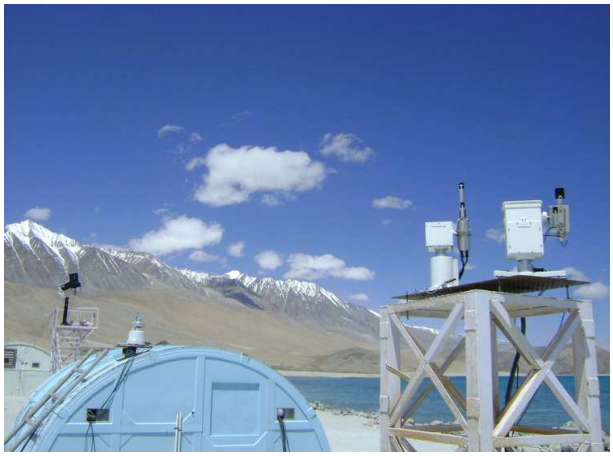


Figure 2.26: Sky radiometer installed at Merak on a 3m tower, beside the observing hut. The IIA-SDIMM on a 4m tower is seen in the background.

using them for analysis, was carried out from the programme lab and office at Bangalore. Use of software developed on IDL platform included analysis of the met data such as wind speed and direction, humidity, estimation of sunshine hours from pyranometer data, estimation of precipitable water vapor, evaluation of the isoplanetic angle, and study of absolute temperature observations at heights up to 15 m to evaluate the behaviour of near ground boundary layer. Figure 2.28 and Figure 2.29.

In the case of NSO-SDIMM and SHABAR, software was provided earlier by the NSO group. Similar software was developed at Bangalore for the IIA-SDIMM. However, due to the technicality of scintillation measures not appropriately representing the seeing at lake sites, a revised inversion code was developed by NSO. This code was procured and suitably adapted to estimate seeing at 6, 16, 26, and 36 m above ground, for both Hanle and Merak. Outstanding conditions are observed at Merak at 26 m height on many days, especially during May and June.

(S. P. Bagare, S. S. Hasan, A. K. Saxena, T. P. Prabhu, Rajendra B. Singh, Sangita K. Padhy, Namgyal Dorjey, N. Vasantharaju, K. Prabhu, Angchuk Dorje, Dorjai Tsewang, Jorphail Sonam, M. Tashithsering, R. Norboo, S. Tundup, D. Tseten, K. Anjali John., Ramkumar Prabhu, & Wahab Uddin)*

Characterization of aerosol optical properties over Hanle

An extensive study of aerosol optical properties was carried out using the Prede sky radiometer for a

Figure 2.27: The SDIMM telescope with roll off housing, the micro-thermal tower, and the observing hut at Devasthal site, which is about 32m lower on the ridge, to the south, with respect to proposed site for 3.6 m telescope.

25 month period from December 2007 to December 2009. The observational data were screened and processed using inversion and radiative transfer models described in Skyrad.pack code, developed by Nakajima of Tokyo University. The performance parameters of the instrument such as the accuracies of sun tracking, sun sensor level, and calibration issues were checked periodically.

The retrieved Aerosol Optical Depth (AOD) values for Hanle are comparable with other such high-altitude sites which have pristine environment. The median values are 0.060 and 0.049 at 400 and 500 nm respectively. The values of Angstrom parameters (α, β) were also evaluated for the period of study. α indicates the presence (or otherwise) of coarse-mode aerosols, while β is a measure of aerosol loading at the site.(Figure 2.30).

The results show that the median value of α varies from 0.998 to 1.235, with a maximum during winter to autumn, and a minimum during spring. The minimum value may be attributed to the presence of coarse-mode particles originating from the surrounding desert. Detailed study of aerosol radiative forcing over the region is in progress. The sky brightness and atmospheric extinction at five wavelength bands are also being evaluated for both Hanle and Merak, as part of the site characterization programme.

(S. P. Bagare, Shantikumar S. Ningombam, Neeharika Verma, Rajendra B. Singh & Erik J. Larson)*

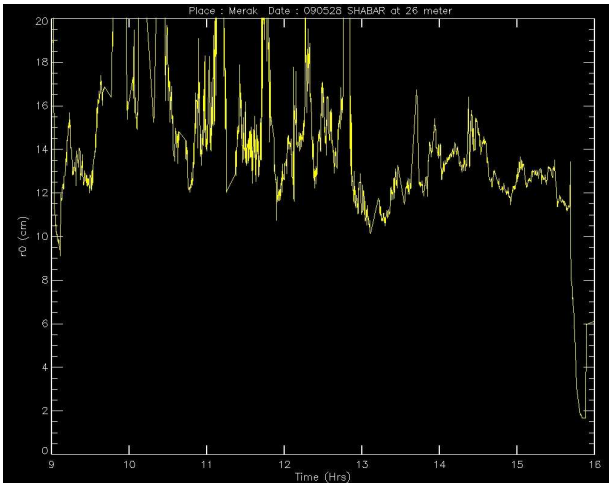


Figure 2.28: Long spells of outstanding (sub-arcsec) seeing conditions at Merak on 28th May 2009, at a height of 26 m above ground, evaluated using SHABAR.

Environment impact and feasibility study

The Institute commissioned the IISc to carry out environment impact and feasibility studies related to locating NLST near the Pangong lake incursion at Merak village in the Leh-Ladakh region. The environment impact study included a land cover analysis, reasons for selecting the proposed site, methods used to identify, predict and assess impacts (such as flora, fauna, bird migration, water quality etc), possible impact on the environment, and finally the environment management plan. The report concludes that the project activities will involve minimal environmental impact and have suggested various mitigation measures, that are easy to implement, to eliminate even the minor environmental effects that might occur.

A site feasibility study in terms of geotechnical and structural engineering was also carried out, that covered: (a)geological and geotechnical issues like possible alternative foundation systems and ground improvement if any along with alternatives; (b)Site drainage characteristics and suggested measures to drain out excess water from the area; (c)Preliminary studies on feasibility of the proposed tower structure for environmental loading conditions (like wind, snow and seismic); (d)Availability of material locally for preparing concrete for the tower structure; (e) Suitability of the material for preparing concrete of required strength.

(S. S. Hasan, T. P. Prabhu, K. E. Rangarajan & Ramachandra Reddy

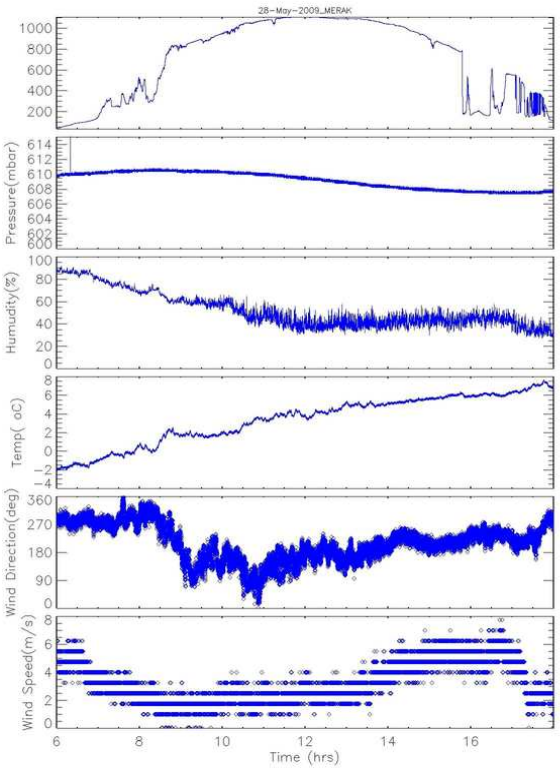


Figure 2.29: The met conditions of irradiance, atmospheric pressure, humidity, temperature, wind direction and wind speed on 28th May 2009.

Fabrication and Installation of NLST

A technical document for the "Expression of Interest" for the fabrication, testing and installation of NLST was brought out and put up on the IIA website. Several companies expressed their interest. Prebid technical discussions with the short-listed companies were held and an addendum to the document was brought out.

(A. K. Saxena, T. P. Prabhu, B. Raghavendra Prasad, K. E. Rangarajan, K. Sankarasubramanian, B. Ravindra, R. Banyal, Nagabhushan, P. K. Mahesh, Sriram & J. P. Lancelot)

Detailed Project Report

A Detailed Project Report (DPR) was brought out from the input given by the NLST team and submitted to the DST secretary and the Governing Council. Small sample of topics covered in the report are: inadequacy of present optical solar astronomy facilities in the country, why a 2m telescope, ben-

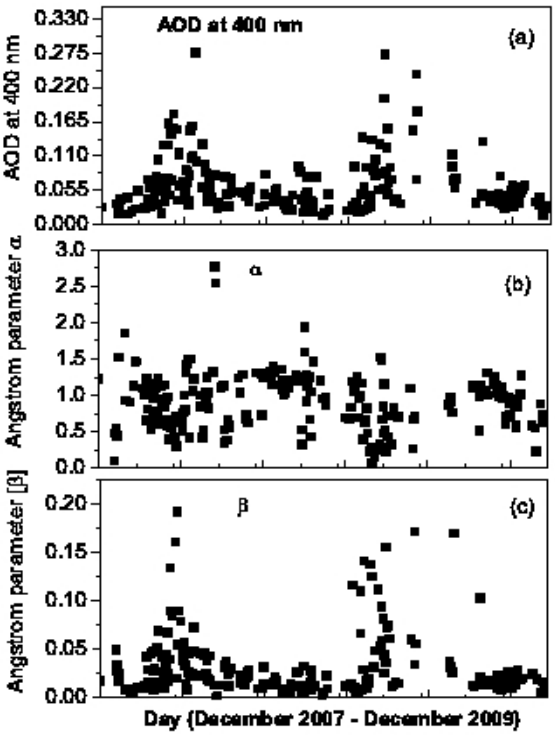


Figure 2.30: Variability of AOD at 400 nm along with the estimated Angstrom parameters (α, β) for Hanle.

efits science and technology from the project, science objectives of the project, technical specifications and concept design of NLST, focal plane instruments envisaged, results from site characterization programme, the role of public outreach in NLST, data management, Human Resources Development, potential users of NLST, work schedule, Budget, NLST with reference to International facilities, night time astronomy with NLST and recommendations of the Indian solar community.

(NLST Team)

2.11.2 Thirty Meter Telescope Project

India's Participation in the Thirty Meter Telescope Project

After three years of deliberations at the institutional and national levels on the pros and cons of participating in one of the three mega projects (GMT, TMT and EELT), the astronomy community in the country, under the GSMT-India group, spear-headed by three research institutes, namely IIA, Inter-University Centre for Astronomy & Astrophysics, and Aryabhata Research Institute of Observational Sciences, submitted a detailed project report titled *India's Participation in an International Giant Segmented Mirror Telescope Project* to the Department of Science & Technology (DST), Government of India in February, 2010. The report dealt with three main aspects for the participation which are; a) Need of Participation in the international project, (b) selection of the most suitable project among three international optical and IR ground-based projects, (c) Optimum level of participation and the strategy to develop required human resources to make of the facility when it is ready.

The need for the participation in one of the projects was a consensus decision and this was expressed by the community at various national meetings.A brief account is given on the selection of a suitable project among the three projects. Evaluation was done in detail with a set of criteria which are: (a) Scientific objectives of the community, (b) Synergy with astronomical facilities in India, (c) Technological realization of the projects, (d) Partnership model and Project management, (e) Cost of the projects and Current Partner commitments, (f) Guarantee and Level of in-kind participation, (g) Human Resources Capacity Building, (h) Suitability of technology development. After careful considerations of each of these criteria the evaluation committee, setup by the Directors of participating institutes, made a strong case for India's participation in the Thirty Meter Telescope (TMT) project. The TMT project is led by Caltech and Univ. Of California and the other members are Canada, Japan, China, and India. The project has chosen Mauna Kea, Hawaii as the site for the TMT observatory which is scheduled to begin construction in 2013 and completed by 2019.

The report was discussed at various high level forums called by the DST, and reviewed by a national advisory group set-up by the DST for this purpose. The process culminated in a public announcement by Prithivraj Chavan, the Hon'ble Minister for Science and Technology, Government of India, and Dr. T. Ramasami, Secretary, Department of Science and Technology, Government of India, on 24th June, 2010, on India's decision to join the TMT project as an observer with a strong intention of becoming a full-partner in due course of time.

The observer status is typically for a period of 2 years or until the construction of the project begins. This would provide ample opportunities for

both the TMT consortium and a prospective partner to have detailed discussions to achieve a comprehensive understanding of the partnership. As an observer, TMT-India would participate in the TMT project board, as well as in all the science and technical meetings. It is envisaged that, by the end of the observer period, TMT-India would have demonstrated technological capabilities for various telescope and observatory subsystems of interest. Based on the technology demonstration, TMT-India would submit a detailed proposal to the DST for a full partnership with the TMT project. As per the current TMT project schedule, it is expected that TMT-India will complete the preparation of the full proposal and submit to the DST around by the end 2011.

TMT-India representatives have been participating in all the decision-making processes: development of the partnership model, the observatory operational document, TMT project organisational structure, work share among partners, and science and instrumentation priorities for the TMT.

TMT-India In-kind contributions

TMT and TMT-India agreed on a formula of 70% in-kind and 30% cash contributions to the project. To fullfil the goal, TMT-India and TMT technical teams had extensive visits and meetings with various industries in the country to explore in-house capabilities to develop systems or sub-systems to the TMT projects. Based on the existing capabilities TMT-India negotiated with the TMT project to provide the following high technology systems to the project: (1)Primary mirror polishing, (2)Primary mirror controls: Edge sensors and actuators, (3)Primary mirror segment assembly systems, (4)TMT-India participates in one of the three instrument development, (5)Observatory control software. Negotiations are on to set-up a TMT science centre in India. The successful development of these systems would largely benefit India in the long run to build medium 8-10m class telescopes within the country.

Technology demonstration

Like any other partner, the work packages assigned to TMT-India need to undergo technology demonstrations. It is agreed that irrespective of the outcome of the technology demonstration, money spent by India on technology development shall be accounted as TMT-India's in-kind contribution to the TMT project, which would eventually translate to observing time. A detailed proposal with title "India's participation in the Thirty Meter Telescope Project: Proposal for Technology Capability Development and Demonstration" was submitted to the DST in November, 2010. The DST has approved this proposal and sanctioned funds to carry out work on the technology demonstration and prototyping. The team is now in the process of selecting industrial units within the country in order to demonstrate the above said technologies. Request for proposals for manufacture of actuators and edge sensors prototype have been floated on the IIA webpage and also announced in the national newspapers.

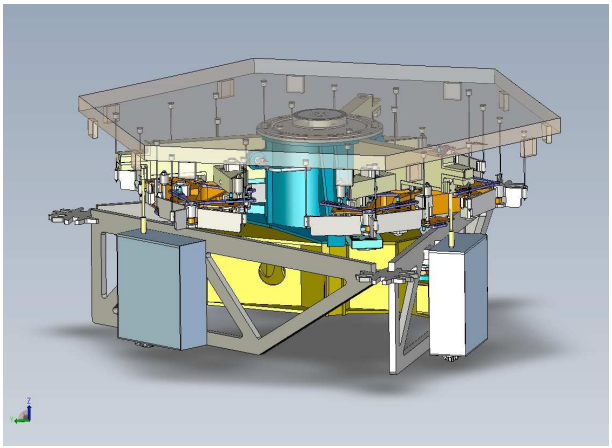


Figure 2.31: The current work-share model of the TMT provides opportunity for India to provide a portion of polished segments, Actuators, Edge sensors, and SSA which together form main part of the M1 mirror system.

(B. Eswar Reddy, Coordinator, TMT-India)

Chapter 3

Student Programmes & Teaching Activities

3.1 Academic Programmes

IIA conducts three different academic programmes leading to Ph.D. degree. They are: (i)Ph.D. programme; (ii)integrated M.Sc-Ph.D. programme; and (iii)integrated M.Tech-Ph.D. (Tech.) programme. For the selection of students to the above three programmes for 2010-2011, advertisement was given in leading national newspapers inviting applications from motivated and academically bright students. Posters of the advertisement was also sent to colleges / universities across the country. Based on the performance in the national level screening test (IIAST) conducted during December 2009 students were called for personal interview at IIA, Bangalore in January 2010. Those who could not attend the interview were called for personal interview in June 2010. Students who had qualified through GATE / JEST / CSIR-UGC-NET scoring high marks were also called for the personal interview in June 2010.

The break-up of students who were selected for the different programmes is as follows:

(i)Ph.D. programme (7 out of 85 candidates short-listed for interview) (ii)integrated M.Sc-Ph.D. programme (5 out of 41 candidates short-listed for interview) (iii)integrated M.Tech-Ph.D. (Tech.) programme (4 out of 59 candidates short-listed for interview).

The number of students who joined the different programmes are:

(i) Ph.D. programme (3 students) (ii) integrated M.Sc-Ph.D. programme (2 students) (iii) integrated M.Tech-Ph.D. (Tech.) programme (4 students)

The following staff members taught courses (theory classes and practicals) to the students of the above three catagories:

G. C. Anupama, K. Anupama, D. Banerjee, R. Banyal, B. Ravindra, R. K. Chaudhuri, S. Chatterjee, V. Chinnappan, S. Giridhar, A. Goswami, U. S. Kamath, V. Krishan, S. Faseehana, J. P. Lancelot, G. Pandey, A. Mangalam, S. P. K. Rajaguru, R. Ramesh, K. E. Rangarajan, S. K. Saha, A. Satya Narayanan, A. K. Saxena, S. Sengupta, T. Sivarani, C. Sivaram, C. S. Stalin, G. Srinivasulu, A. Subramaniam, K. R. Subramanian, F. Sutaria, and P. R. Vishwanath.

3.1.1 Visiting internship programme

The visiting students internship programme is conducted by the Indian Institute of Astrophysics (IIA) with the aim to promote scientific research interest in college and university students. Students selected for this programme work on specific projects that form a part of the ongoing research at IIA. Based on the nature of the project, the students will be asked to work at either the main campus of IIA in Bangalore or its field stations. Students carrying out their Ph.D. in universities, and would like to visit IIA for collaboration are also encouraged to apply for this programme. During last year, about ten students carried out internship at IIA. One of the students was from Supelec, a French Graduate School of Engineering. There were also two Ph.D. students who visited the institute under this category for collaborative work: one was from Cochin University of Science and Technology, and the other from IISER, Kolkata. The Ph.D. students worked respectively with A. Subramaniam, and B. Ravindra.

3.1.2 Ph.D. Awarded

Malay Maiti was awarded the Ph.D. degree for his thesis titled *Theoretical and Observational Study of Substellar-Mass Objects* which was submitted to the Mangalore University on 17th April, 2010.

He carried out the above work under the guidance of *Sujan Sengupta.*
Girjesh R. Gupta a JAP student, was awarded the Ph.D. degree for his thesis titled *On the Nature of Propagating MHD Waves in the Solar Atmosphere* which was submitted to the Indian Institute of Science on 6th December, 2010. He carried out the above work under the guidance of *D. Banerjee.*

3.1.3 Completion of Ph.D. Theses

The following students submitted their thesis:

Veeresh Singh submitted his thesis titled *Multi-Wavelength Studies of Active Galaxies* to Calicut University on August 18, 2010. The research was done under the supervision of *P. Shastri.*

S. Ramya submitted her thesis titled *A Comprehensive Study of Star Formation in Blue Compact Dwarf Galaxies* to the Bangalore Univsersity in November 2010. The research was done under the supervision of *T. P. Prabhu.*

A. C. Pradhan submitted his thesis titled *Diffuse Radiation from the Magellanic Clouds* to the Mangalore University on 1st April, 2011. The research was done under the supervision of *J. Murthy.*

Rumpa Choudhury submitted her thesis titled *Studies of Young Stellar Objects and their Environment* to the Calicut University on 31st January, 2011. The research was done under the supervision of *H. C. Bhatt.*

3.1.4 Completion of M.Sc

The following students from the 1st batch of the above programme have completed their M.Sc degree under the IIA-IGNOU integrated M.Sc-Ph.D. programme, and commenced their Ph.D. research.

Avijeet Prasad under the guidance of *Arun Mangalam* submitted his thesis to the School of Science, IGNOU, for his M.Sc degree in Physics and Astrophysics, on 15th June, 2010.

Manpreet Singh under the guidance of *S. Chatterjee and H. C. Bhatt* submitted his thesis titled *Extraction of Solid State Features of Carbon Dust Grains in the ISM* to the School of Science, IGNOU, for his M.Sc degree in Physics and Astrophysics, on 15th June, 2010.

Ramesh Pandey under the guidance of *B. P. Das* submitted his thesis titled *Manifestation of the Electric Dipole Moment of the Electron in an Atom* to the School of Science, IGNOU, for his M.Sc degree in Physics and Astrophysics in 15th June 2010. He left the institute after M.Sc.

All the above three students scored ranks in the national level CSIR-NET examination held during June 2010. Avijeet Prasad and Ramesh Kumar secured 3rd and 29th rank respectively in the JRF category. Manpreet Singh scored 29th rank in the lectureship category.

3.1.5 Completion of M.Tech.

The following students from the 1st batch of of the above programme have completed their M.Tech. degree under the IIA-CU integrated
M.Tech-Ph.D. programme, and commenced Ph.D. research.

Anantha Chanumolu under the guidance of *G. Pandey and S. Sriram* submitted her M. Tech thesis titled *VBT High Resolution Echelle Spectrometer* to the University of Calcutta, on 15th September 2010. She has received her degree.

Arun Surya under the guidance of *S. K. Saha* submitted his M. Tech thesis titled *Imaging Processing techniques* to the University of Calcutta, on 15th September 2010. He has received his degree.

Sajal Kumar Dhara under the guidance of *K. E. Rangarajan* submitted his M. Tech thesis titled *Development of Faster Algorithm for Shack-Hartmann Wavefront Sensor* to the University of Calcutta, on 15th September 2010. He has received his degree.

K. Sasikumar Raja under the guidance of *R. Ramesh* submitted his thesis *Development of an Antenna System to Observe the Circularly Polarized Radio Emission from the Solar Corona at Low Frequencies* to the University of Calcutta, on 15 September 2010.

Vineeth Valsan under the guidance of *J. P. Lancelot* submitted his M. Tech thesis titled *Design Aspects of Stokes Polarimeter for Solar Observation* to the University of Calcutta, on 15th September 2010 and has graduated with an M.Tech degree.

Venkata Suresh Narra under the guidance of *C. S. Stalin* submitted his M.Tech. thesis titled *Back Focal Component Calibration of Ultraviolet Imaging Telescope (UVIT) on Board ASTROSAT* to the University of Calcutta, on 15th September 2010.

(Board of Graduate Studies)

3.2 International Research Experience for Students (IRES)

Under the International Research Experience for US Graduate Students (IRES) programme, sponsored by the National Science Foundation of USA, IIA hosted the following students during June - August of 2010: Megan Force from the University of Vermont, VT, Christene Lynch from the University of Iowa, IA, Gordon Macdonald from California State University, Northridge, CA, and Christopher Vorren from the University of North Carolina, NC.

The IRES students with Siraj Hasan (Director), Harish C. Bhatt (Dean-Academic), and S. K. Saha (Chair of the BGS).

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. After completing an initial three year period of successful running, this programme received a positive review and continued funding from the NSF and 2010 is the fourth year of the programme at IIA. The students associate with a faculty member at IIA for a research project, and also undertake visits to IIA's observatories and field stations. Cultural and social events are interleaved too. The programme covers the students travel and stay and allows them to extend their return date in order to be a tourist in India at the end of the research period.

IRES students visiting the Kodaikanal Solar Observatory, Kodaikanal, from the left Christene, Gordon, Christopher and Megan.

Megan Force worked with G. Pandey and Muthumariappan on *Spectroscopic study of Beta Cephei star HR 4853*, Christene Lynch worked with G. C. Anupama on *Photometric and spectroscopic evolution of Supernovae*, Gordon MacDonald worked with S. P. Rajaguru and Siraj Hasan on *Studies of waves in sunspots using spectro-polarimetric and imaging observations* and Christopher Vorren worked with K. M. Hiremath on *Theoretical probing of the solar core rotation.*

(S. P. Rajaguru & T. Sivarani)

3.3 Summer School in Physics and Astrophysics

The summer school in Physics and Astrophysics for the year 2010 was held at the Kodaikanal Observatory, Kodaikanal, during 17th – 28th May, 2010. The basic aim of the school, which is being co-ordinated by the Board of Graduate Studies every year, is to expose students of various degree courses to the ongoing research activities in the various fields of Astronomy and Astrophysics, and to motivate them to take up a career in Astronomy and Astrophysics.

There were a total of 25 participants for the school. Out of these, 14 students were selected only for the school and 11 students were selected for the summer internship programme at IIA, Bangalore.

Participants of the *Summer School on Physics and Astrophysics.*

Twelve academic staff members of the institute delivered lectures in the school on a wide range of topics in Astronomy and Astrophysics. The inaugural lecture was delivered by S. P. Bagare wherein he presented an overview of the ongoing academic activities of the institute, upcoming large astronomical projects in India and the enormous opportunities available for the younger generations. He also gave lectures on general Solar physics, the available instrumentation to study Sun and upcoming large ground-based and space-based facilities in the country for the study of Sun. U. S. Kamath introduced the concepts of the co-ordinate systems in Astronomy, telescopes, detectors and measurements in Astronomy. T. Sivarani gave lectures on star formation and stellar nucleo-synthesis. In addition to that, she also demonstrated spectroscopic data reduction techniques in optical astronomy. K. Sundara Raman gave lectures on the transient activities of the Sun, their impact on space weather, and the instruments available at the Kodaikanal Observatory to study solar phenomena. The properties and nature of the dust in the Universe were discussed by C. Muthumariappan. Firoza Sutaria described the physics of stellar structure and evolution. Lectures on galactic astronomy were delivered by Annapurni Subramaniam. C. S. Stalin spoke on Extragalactic astronomy. He also delivered a talk on the basics of photometric data reductions and also helped the participants to have hands-on experience on photometric data reductions. Lectures on brown dwarfs and extra-solar planets were given by Sujan Sengupta. The participants were introduced to X-ray and gamma-ray astronomy by P. R. Vishwanath. He also talked about the various activities taken by the institute to study the gamma-rays emitted by astronomical sources. During the school two special evening lectures were also arranged. The two talks titled *Is there a final theory ?* and *Recent discoveries in Neutrino Physics* were delivered by G. Rajasekaran of the Institute of Mathematical Sciences, Chennai. He also gave an overview of the upcoming Indian Neutrino Observatory (INO). Lectures on Relativistic Astrophysics were given by Arun Mangalam. He gave a course on *Black Holes and Cosmology*, 20th – 22nd May, 2010, An introductory lecture on Radio astronomy techniques was delivered by R. Ramesh. He also gave lecture on the different solar phenomena that can be studied at radio frequencies. A. Satya Narayanan gave lectures on Magneto-hydro dynamics.

The school was co-ordinated by C. S. Stalin and local arrangements were carried out efficiently by the staff members of the Kodaikanal Observatory under the guidance of K. Sundara Raman.

The 11 students who were selected for the internship also worked with the following staff members at the institute: K. P. Raju, U. S. Kamath, T. P.

Prabhu, A. K. Saxena, F. Sutaria, A. Goswami, K. N. Nagendra, S. P. Bagare, R. Kariyappa, J. Murthy, and C. S. Stalin.

(C. S. Stalin)

3.4 The Third IIA-PennState Astrostatistics School

IIA and the Center for Astrostatistics, PennState University, USA, came together for the third time, to organise the IIA-PennState Astrostatistics school on the campus of the Vainu Bappu Observatory, Kavalur during 19th – 27th July, 2010. A total of 29 astrophysicists participated, from both within the country and abroad.

The IIA-PennState schools are a response to the current twin challenges that face empirical astrophysicists, viz., the need for rigour in the application of statistical methods to data analysis, and the need to invoke a diverse set of statistical techniques for the complex, automated analytical processes that are routinely required in data mining of large multi-wavelength data sets.

The schools provide a strong conceptual foundation in modern statistics as well as a repertoire of state-of-the-art statistical tools applicable to astrophysical problems. The schools are distinctive in being an inter-disciplinary collaboration between IIA, Center for Astrostatistics of Pennsylvania State University, USA, and the Indian statistical community. For the last several years, the Center for Astrostatistics has run a very successful annual summer school on Astrostatistics in PennState. The IIA-PennState schools were modelled on the PennState schools, and the two series of schools have begun to synergetically build on each other in their content and faculty. The school was aimed at astrophysics practitioners at all levels Ph.D. upwards.

Like the first two schools, the 3rd IIA-PennState school was heavily oversubscribed, and had participants from a diverse set of backgrounds. The 29 participants included four from IIA, six from the Indian university sector (two faculty and four Ph.D. students), besides faculty, post-docs and students from other astrophysics research institutes of the country, viz., IISc, ISAC, PRL and TIFR. As Siraj Hasan, IIA Director, said while inaugurating the school, the school was kept international in its reach in keeping with the spirit of all of IIA's acitivities, and there were three Ph.D. students from Spain, one from Germany, and a post-doctoral scientist from South Africa.

The faculty of the school were Jogesh Babu of the Centre for Astrostatistics, PennState University, USA, Bhamidi Rao and Rajeeva Karandikar from the Chennai Mathematical Institute, Sushama Bendre from North-Eastern Hill University, Shillong, Mohan Delampady from Indian Statistical Institute, Bangalore, Thriyambakam Krishnan from Strand Life Sciences, Bangalore, Arnab Chakraborty from St. Xavier's College, Kolkata, and Deepayan Sarkar from Indian Statistical Institute, Delhi.

A notable feature in the course content was that prior knowledge of statistics was not a pre-requisite. However, since valid and rigorous application of statistical tools require a conceptual understanding of the methodology, the content of these schools are designed to be a mix of prescriptive methods and the their theoretical foundation. 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 mainly by Eric Feigelson from the Center for Astrostatistics, PennState. The tutorials were primarily designed by Arnab Chakraborty in the R software environment, which is the current standard in research-level statistical computation and is also open-source and multi-platform.

For the purposes of the lab sessions, Anbazhagan Poobalan and his computer management team at the Vainu Bappu Observatory set up individual dual platform laptops for the participants in the lecture hall with the R software installed, and networked them to a local data-server. The tutorial sessions were conducted by Arnab Chakraborty and Deepayan Sarkar. The statistics lectures and tutorials 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 has all the lecture notes as well as the tutorials and data sets.

Several of the participants were given a slot upon request, to discuss their on-going individual research problems with the statisticians. Those participants that made use of this feature, then presented a summary of their problems and the inputs from the statisticians, to the whole 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 two communities. The tranquil venue of the Vainu Bappu Observatory greatly facilitated the intense engagement that was demanded of

Participants of the *3rd IIA-PennState Astrostatistics School* at the Vainu Bappu Observatory engaged in a tutorial.

the school. Although the dates of the school were selected to coincide with the lull-period in observing activity, on occasion when the clouds parted, the participants and statisticians did have an opportunity to do sky-watching during the post-dinner hours.

The school came together because of the diligent efforts of an intensely committed organsing crew that had Ravinder Banyal, Varsha Chitnis, Chinnathambi Muthumariappan, Anbazhagan Poobalan, Shalima Puthiyaveettil, and Shivarani Thirupathi, with the administrative support of Dr. P. Kumaresan, S. Rajendran, S. B. Ramesh, M. P. Parthasarathy, A. Narasimharaju, and K. Lakshmaiah, and most critical of all, the zealous efforts by the entire VBO team that has been a feature of every school. Prajval Shastri and Sabyasachi Chatterjee from IIA and Jogesh Babu of PennState were the co-ordinators.

(Prajval Shastri)

3.5 UGC Workshop

S. P. Bagare co-organized, with the Department of Studies in Physics, University of Mysore, a one day workshop sponsored by the UGC (under the DRS-SAP scheme) on "Recent Trends in Astrophysics" on 28th March 2011. Lectures were given by S. P. Bagare, Jayanth Murthy, and Arun Mangalam of IIA on *The Sun and the Solar System, The Life Cycle of Stars*, and *Extra Galactic Universe*, respectively.

(S.P. Bagare)

3.6 Individual Teaching Activities

3.6.1 Research Guidance

S. P. Bagare co-guided *R. Shanmugavel*, a student from Madurai Kamaraj University, on the topic *Molecular Band Spectra in Astrophysical Environments*. He was awarded the Ph.D. from Madurai Kamaraj

University, in March – April, 2010.

R. Banyal is a co-guide with *P. Parihar* for the project titled *Development of Lunar Scintillometer for the NLOT* of Anusha Kalyaan affliated to Sastra University, Thanjavur.

S. Chatterjee co-supervised the Ph.D. research of Rezvan Ravanfar Haghighi (affiliated to the All India Institute of Medical Sciences), on the topic *Characterization of the coronary artery plaque.*

B. P. Das is supervising *Arya Dhar* a senior research Fellow for his Ph.D. thesis on *Novel Quantum Phases of Ultracold Atoms in Optical Superlattices* and *Manpreet Singh* a junior research Fellow for his Ph D thesis on *Theoretical Studies of Mixtures of Ultracold Atoms in Optical Superlattices.*

R. T. Gangadhara is supervising *Dinesh Kumar* for his Ph.D. thesis on *Polarization of Pulsar Radio Waves.*

S. Giridhar is supervising *Sumangala Rao* for her Ph.D. thesis titled *Spectroscopic Studies of RV Tau Stars and other post-AGB Stars to Understand Late Stages of Evolution of Low and Intermediate Mass Stars.* Giridhar is also guiding *A. B. Sudhakara Reddy* whose thesis is on *Deriving Abundance Patterns for Selected Open Clusters to Chemically Tag them and Learn more about the Structure and Evolution of our Galaxy.*

S. Goswami is supervising *Drisya Karinkuzhi*, a Ph.D. student, on the topic *Studies on Carbon-Enhanced Metal-Poor Stars.*

K. M. Hiremath guided *Kristopher Vorren*, University of North Carolina, USA, under the IRES-2010 programme, during the period of June – August, 2010. The project was on *Probing of Solar Core Rotation.* Hiremath also guided two MSc Physics students *Lijo Thomas* and *Sr. Mary Gracy* from Christ College, Department of Physics, during December 2010 – March 2011 for their project on *Study of Solar Limb Prominences: Dynamics and Energetics.*

U. S. Kamath guided *Jyoti A. Jadhav* from Pune University for the project on *The Distance to RS Ophiuchi* under the IIA Summer Student Programme (June – July 2010); guided H. D. Supriya for the project on *Observing Novae in Nearby Galaxies using HCT* from February – April 2011.

R. Kariyappa guided A. Agrawal from BITS, Pilani, for his 6-months project on *Coronal Rotation from XBPs Observed with Hinode/XRT* during July – December 2010. He is also guiding L. P. Chitta, an IIA Ph.D. student, registered under Pondicherry University for his thesis work on *Fine Scale Features of the Sun.* He continues to be a co-guide for S. T. Kumara for his Ph.D. thesis on *Understand the Solar Variability from Spatially Resolved Images* at the Department of Physics, Bangalore University - since 2008.

A. Mangalam is supervising the Ph.D. thesis of Prashanth Mohan on the topic *Observational Signatures from Black Holes* and Avijeet Prasad on the topic *Force Free Fields and Magnetic Helicity* under IIA-IGNOU I-Ph.D. programme.

J. Murthy supervised the following students: A. C. Pradhan who submitted his thesis on *Diffuse radiation from the Magellanic Clouds* to the Mangalore university; V. S. Parvathi from the Physics department, Calicut University has submitted her thesis on *Carbon Abundances in the ISM.* He is also guiding *K. Preethi* a Ph.D. student from Christ University, Bangalore on Interstellar Gas Abundances and *A. Kalyaan* a summer student, on Radiative Transfer in Interstellar Clouds.

K. N. Nagendra is supervising the Ph.D. research of L. S. Anusha, IIA, from January 2008 on her Ph.D. thesis titled *Advanced Numerical Methods for Polarized Radiative Transfer: Astrophysical Applications*, and of H. N. Smitha, IIA, from June 2010 on her Ph.D. thesis titled *Application of Polarized Line Formation Theory to the Second Solar Spectrum.*

G. Pandey is guiding B. P. Hema towards her Ph.D. on *Observational Studies of Hydrogen Deficient Stars.*

T. P. Prabhu guided Soumi Pal, an M.Tech.student on *Automation of an All-Sky Camera for Hanle* and Jaspreet Singh Randhava, a summer student, on the project titled *Atmospheric Water Vapour at Hanle.T. P. Prabhu & G. C. Anupama* are guiding Amit Shukla on his Ph.D. thesis titled *Radiation Mechanisms of Very High Energy Gamma Ray Sources.*

S. P. Rajaguru supervised Gordon MacDonald of California State University, Northridge, CA USA, under the IRES programme coordinated by IIA, Bangalore and NSO (NSF) of USA during the academic year 2010 (June – August) on the project *Spectropo-*

larimetric Analyses of Waves over a Sunspot Region.

K. P. Raju is guiding Suraj G. Gupta, an M. Sc. student, Mumbai University under the IIA Summer Project Students' Programme during 15th May – 15th July, 2010 on the topic *Synoptic Solar Studies from Kodaikanal Archival Data.*

K. E. Rangarajan taught a part of *Fundamentals of Astrophysics* course for IIA-CU integrated MTech-Ph.D. students during March 2010 to April 2010 and March 2011 to April 2011.

S. K. Saha is guiding an IIA-CU Integrated M. Tech.-Ph.D. student, Arun Surya, since October, 2009.

A. K. Saxena guided a BE summer student Rupa Maity from JIETSETG College, Jodhpur, for her project on *A Microprocessor Based Drive System for a 12 inch Telescope.*

T. Sivarani supervised Anantha Chanumolu an M Tech. Ph.D. student working on the Hanle echelle project on *High Resolution Fibre Fed Echelle Spectrograph: Calibration and Characterization for Precise Radial Velocity and Chemical Abundances.*

P. Shastri supervised the Ph.D. research of Veeresh Singh on *A Multiwavelength Study of Active Galaxies.*

C. S. Stalin guided Mr. Venkata Suresh Narra for his M.Tech. thesis on *UVIT Detector Ground Calibration* during the period November 2009 – August 2010. He is guiding Mr. Rathna Kumar for his Ph.D. thesis on *Lensed Quasar Monitoring.*

K. Sundara Raman guided 2 M. Phil students of Mother Teresa Women's University, Kodaikanal in their dissertation work during November 2010 - February 2011 in Solar Physics. He also guided graduate (Physics) students of Mother Teresa Women's University in the topics on Solar Physics.

F. Sutaria supervised summer student Rajeswari Kamalanathan on a project titled *High energy Emission from Neutron Stars.*

3.6.2 IIA/JAP programme courses & other lecture series

S. P. Bagare taught a course on *Physical Astronomy* for the Integrated M.Sc. programme of the University of Mysore, March – June 2010.

R. Banyal is a co-guide with *P. Parihar* for the project on *The Development of the Automated Scintillation Monitor* by Tarun Sharma, an IIA Integrated M.Tech-Ph.D. student. *R. Banyal* is also co-guiding Jyotirmay Paul with *B. Ravindra* for the project titled *Computer Control and Automation for Scanning Fabry-Perot Based Narrow Band Imaging System.* J. Paul is an IIA Integrated M.Tech-Ph.D. student.

R. Banyal conducted a *General Physics Laboratory* course for the IIA Integrated Ph.D. programme for the first semester, from August 2010 - January 2011. He also lectures on *Error analysis* to the 1st year I-Ph.D. students for the experimental physics course. Banyal conducted an *Optics Laboratory* course for IIA Integrated Ph.D. programme for the 3rd semester, August 2010-January 2011.

S. Chatterjee along with Vinod Krishan taught the course on *Quantum Mechanics* in the IIA Integrated Ph.D. programme.

S. Giridhar taught a course on *Astrophysical Concepts* for the M.Tech-Ph.D. programme.

A. Goswami taught a course, for the second semester, for the JAP students on *Stellar and High Energy Physics* and I Ph.D. course: Nuclear and Particle Physics 2nd Semester, in 2010 and 2011 from January – June.

U. S. Kamath taught the following courses: *Computational Astrophysics* (M.Tech-Ph.D. April 2010), *Spherical Astronomy* and related topics (Int. Ph.D. and M.Tech-Ph.D. August 2010), *Astrophysical Techniques* (M.Tech-Ph.D., JAP, IPh.D. August – September 2010), *Computational Astrophysics* (M.Tech-Ph.D. March 2011). He also gave lectures on *Astronomical Concepts* at the Kodai Summer School (May 2010).

A. Mangalam taught the following courses: *Classical Mechanics* (IIA PhD); Astrophysical Concepts: part on relativistic astrophysics (IPhd- MTech, Aug. 2010); *General Relativity & Cosmology* IIA-IGNOU (full course); *Numerical & Statistical Techniques* to the JAP-IIA students, April–May 2010.

K. N. Nagendra taught a part of the course on *Radiative Processes* to Ph.D. and IPh.D. students of IIA during October–December 2010.

G. Pandey & T. Sivarani jointly taught the MTech - "Computational Astrophysics, Statistics and Data Mining" course.

S. P. Rajaguru along with Vinod Krishan taught the course on *Fluids and Plasmas* to the IPh.D./Ph.D. students during August – December, 2010 of the academic year 2010 – 2011.

K. E. Rangarajan taught the JAP course on *Radiative Processes* from 10th August – 10th December, 2010.

S. K. Saha delivered a series of lectures to the IIA-CU Integrated M.Tech-Ph.D. (Tech.) second year students on *Observational Techniques in Astronomy* and *Detection Techniques in Astronomy* during March – April 2010. He also delivered a series of lectures to IIA-IGNOU Integrated M.Sc-Ph.D. third semester students on *Astronomical Techniques* in 2010 and to the JAP students during their first semester course on Astronomical Techniques in 2010.

T. Sivarani taught a part of the course on *Data mining* to the M Tech-Ph.D. students.

C. S. Stalin taught a course on *Astrophysical concepts* for the M.Tech-Ph.D. students during the period 16th July – 6th August 2010.

A. Subramaniam taught a part of the course, 'Astrophysical concepts' for the III Semester IPh.D. students November – December 2010.

F. Sutaria taught the course *Stellar Structure and Evolution* in the Ph.D. and Integrated Ph.D. programmes.

P. R. Vishwanath gave courses in IIA (January semester 2011) to Ph.D. and JAP students on (i) High Energy Astrophysics for Ph.D. and JAP students and (ii) Particle Astrophysics for Integrated Msc-Ph.D. students.

3.6.3 Pedagogical lectures & courses taught outside IIA

S. P. Bagare gave a lecture on *The Sun and the Solar System,* at the one day workshop sponsored by the UGC (under DRS-SAP scheme) on "Recent Trends in Astrophysics" held at the Department of Studies in Physics, University of Mysore, on 28 March 2011.

S. Chatterjee gave a series of five lectures on *Spectroscopy and radiative transfer*, to M.Sc. students of the Mohan Lal Sukhadia University, Udaipur, 4-9th February, 2011.

K. M. Hiremath taught a course on *Space Plasma* to M.Sc (Physics) students as a Guest Faculty at the Bangalore University during January - March 2011.

A. Mangalam gave the following lectures (a) *Supermassive black holes*, 6th January, 2011, at the UGC sponsored Conference on Astronomy & Astrophysics at Udupi organized by Poornaprajna College, Mangalore University; (b) *Magnetic universe*, 7 January, 2011, UGC sponsored Conference on Astronomy & Astrophysics at Udupi organized by Poornaprajna College, Mangalore University; (c)*Extragalactic Universe*, 28th March, 20011, Mysore University, Mysore; a semester long course on *Electrodynamics* for undergraduate and graduate students in the Research Education Advancement Programme of the Bangalore Association for Science Education (BASE), Nehru Planetarium.

N. Murthy gave a Certificate course in Astronomy at Christ University (November 2010 – February 2011); He gave a talk on *The life cycle of stars* at the one day workshop sponsored by the UGC (under DRS-SAP scheme) on "Recent Trends in Astrophysics" held at the Department of Studies in Physics, University of Mysore, on 28th March 2011.

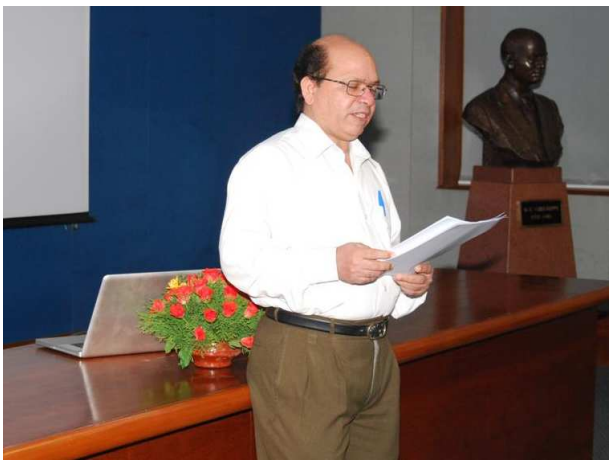
K. E. Rangarajan guided two M.Sc students S. Sreelakshmi and N. Anusha from Christ University on their 6 months M.Sc project titled *Microtelescope Characterization.*

K. Sundara Raman delivered a series of lectures for the M.Sc. and M.Phil Astrophysics students of Mother Teresa University, Kodaikanal, during July 2010 – February 2011.

Chapter 4

Scientific Conferences, Workshops & Lectures at IIA

4.1 In-house Scientific Meeting at IIA



The organisation of 2010 in-house science meeting was overseen by Harish Bhatt, Dean (Academic).

The IIA in-House Scientific Meeting was held on 9th April,2010 for the purpose of discussing research and development within the institute. Different groups, solar, stellar, galactic and extragalatic astrophysics, instrumentation and theoretical physics reported new scientific results and provided status reports on the current projects and facilities. In all, there were 22 oral and 8 poster presentations. Of the oral presentations, 8 were given by students. An important topic of the meeting was the presentation of preliminary results from the 2009 solar eclipse observations.

The following were the highlights of this meetingi: R. T. Gangadhara, P. S. Parihar and R. Ramesh were presented *The Outstanding Research Paper Award* for the year 2009 for their respective papers: *Circular Polarization in Pulsars due to Curvature Radiation,* by R. T. Gangadhara, 2010. ApJ, 710, 29; *Exploring Pre-Main-Sequence Variables of the ONC: the New Variables* by P. Parihar, S. Messina*, E. Distefano*, N. S. Shantikumar, B. J. Medhi, 2009, MNRAS 400, 603; *Radioheliograph Observations of Metric Type II Bursts and the Kinematics of Coronal Mass Ejections* by R. Ramesh, C. Kathiravan, S. S. Kartha and N. Gopalswamy, ApJ, 2010, 712, 188.

The winners of the best paper awards, P. Parihar (left) and R. Ramesh, with Siraj Hasan, the Director.

4.2 Chandrasekhar Centenary Conference

An international conference to commemorate the birth centenary of Professor S. Chandrasekhar was held during December 7-11, 2010 at the Indian Institute of Astrophysics, Bangalore. The main focus of the conference was on research areas in which Chandrasekhar has made seminal contribution during his lifetime. The academic programme consisted of sev-

The audience at the Chandrasekhar Centenary Meeting, IIA.

eral invited talks ranging from stellar structure and evolution, astrophysical fluids and plasmas, stellar dynamics, magnetic hydrodynamic, compact objects, black hole physics, general relativity and stellar and planetary atmospheres. The rich legacy of Chandra's work and its vast impact on subsequent developments in the field of astronomy and astrophysics were highlighted in series of stimulating and inspiring lectures delivered by the eminent scientists both from India and abroad.

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

4.3 The Humboldt Kolleg

A Humboldt Kolleg on *Self-organized criticality: Dynamics of Complex Systems* was hosted at IIA during 2–5 February, 2011. The objective of this multi-disciplinary meeting was to create an interactive space by forging mutually reinforcing interfaces between young researchers and more advanced workers in diverse fields of self-organized criticality research. The kolleg had a total of 76 registered participants including nine researchers from Germany supported by the Alexander von Humboldt Foundation, Germany.

Rolf Saligmann, the Consul General of Germany in Bangalore, formally inaugurated the Kolleg, which was followed by a keynote address by Professor Hans Meinhardt, from the Max Planck Institute for Developmental Biology, Tbingen on *Pattern formation in Biology: local self-enhancement and long range inhibition as the driving force*. The talk evoked a lively

Participants in the Humboldt Kolleg on *Self-Organised Criticality.*

discussion with a large number of questions.

The second day of the Kolleg, was devoted to a wide range of talks on *Self-organization in Chemical Systems* followed by *Self-organization in Biological Systems.* The day's programme concluded by a though-provoking lecture on *Hydrodynamics of the Cumulus Clouds* by Prof. Roddam Narasimha, Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore.

Self-organization in Physical Systems and *Complexity and emergent properties at the interface of chemistry, biology and physics* formed the theme of the lectures on the third day of the Kolleg. Several lectures explored the connections between processes that were truly multi-disciplinary in nature. At the end of the day, there was a meeting of the Humboldt Associations of India in which various ways of strengthening co-operation among the national Humboldt Clubs were discussed.

There were two sessions on the final day dealing with *Dynamics of Complex Systems* and *Self-organization in Social Systems and Linguistics*, followed by concluding remarks by Siraj Hasan. The Kolleg thus covered a wide range of topics and provided a platform for young researchers and experienced scientists from different disciplines to interact. From the discussions several common research areas were identified for establishing a base for sustained long term scientific interactions. A measure of the success of the Kolleg was the enthusiastic participation of a large number of students from various institutions.

(Siraj Hasan)

4.4 3rd Indo-China workshop on Solar physics

Professor Jingxiu Wang (National Astronomical Observatories, China) lighting the lamp at the inaugural session of the meeting. Others present here (from the left) are, Professors Cheng Fang, Arnab Rai Choudhuri, Siraj S. Hasan (Director, IIA) and Takashi Sakurai (NAOJ, Japan).

The 3rd Indo-China workshop on Solar physics in conjunction with the 1st Asia-Pacific solar physics meeting was held in Indian Institute of Astrophysics, Bangalore, during March 21st – 24th, 2011. This meeting provided a good platform for collaborations between Indian and Chinese colleagues. There were 30 minute invited talks and 20 minute shorter contributed talks along with extended poster sessions. The first day was dedicated for an India-China discussion session, where the current and future observing facilities and results from existing facilities from the two countries were presented. Next few days had

the following sessions: From the "Solar Interior to the Solar Surface", "Solar Surface, Active Regions and Magnetic Fields above them", "Corona and the Solar Wind". In addition, one of the evenings was dedicated for a session on solar history and reminiscences. The senior scientists of India and China also had an interactive session in the form of a group discussion for future collaborations. It was also decided to bring-out a conference proceedings which will be published as a special volume in the Bulletin of Astronomical Society of India Conference Series (ASICS). There were 132 participants from India, China and other pacific regions.

(Dipankar Banerjee)

4.5 Discussion Meeting on Space Weather

Professor Archana Bhattacharyya, Emeritus Scientist, IIG, Mumbai speaking on 'Impact of solar disturbances on Earth's magnetosphere and ionosphere'.

A one-day national meeting to discuss "Solar Dynamical Processes as Drivers of Space Weather" was organized at IIA, Bangalore, immediately following the 3rd Indo-China and 1st Asia-Pacific Solar Physics Meeting, on the 25th March, 2011. This meeting made use of the availability of many Indian solar physicists who participated in the preceding meeting, and also had geophysicists and researchers from the field of planetary physics from the Indian Institute of Geomagnetism (IIG), Mumbai, and Physical Research Laboratory (PRL), Ahmedabad. Archana Bhattacharyya, Emeritus Scientist, IIG, and Siraj Hasan, Director of IIA, presided over the meeting. There were focussed discussions on the underlying connection between processes in the solar interior and atmosphere and their influence on space weather. Topics covered included solar activity, and their impact on the interplanetary medium, magnetosphere, ionosphere and the Earth's atmosphere. The speakers included Nat Gopalswamy (NASA), P. K. Manoharan (TIFR, Ooty), D. Pallamraju (PRL, Ahmedabad), Archana Bhattacharyya (IIG, Goa), S. P. Rajaguru (IIA), D. Banerjee (IIA), and R. Ramesh (PRL, Ahmedabad). This session was organized as a precursor to the International Space Weather Initiative (ISWI), a follow-up programme of the successful *International Heliophysical Year 2007* programme.

(S. P. Rajaguru)

4.6 Lectures at IIA

4.6.1 19th Bicentennial Commemorative Lecture

Professor Andre Beteille, Professor Emeritus, University of Delhi presented IIA's 20th Bicentennial Commemorative Public Lecture on April 16, 2010. Professor Beteille, a Padma Bhushan recipient and a prolific lecturer and writer, presented a talk entitled: *Can Rights Undermine Trust? How Institutions Work and Why they Fail.*

In his talk, Professor Beteille argued that social rights and trust are but two sides of the same coin for the well-being of collective life. He went on to compare domestic institutions such as family and institutions of science and scholarship. Although widely differing in their scope and scale within society, these two institutions work best when the rights of the constituent members and the function that these institutions provide are based on the mutual trust vested in the members by the society (for the functioning of the institution) and the trust that the members have with society in protecting their rights.

4.6.2 Founder's Day

IIA celebrated Founder's day on 10th August, 2010, the birthday of Vainu Bappu. For IIA, Founder's Day is an occasion to come together and reflect on progress made towards its long-term vision, the foundations for which were laid by its founder. Founder's day events this year included a gathering of all IIA members in the Library, where a picture of Vainu Bappu was garlanded by the director followed by a release of a pamphlet that collects together, from the IIA archives maintained by the library, the historic events that characterised the life of Vainu Bappu and his leadership at IIA.

Siraj Hasan in conversation with Andre Beteille and Shakuntala Narasimhan after his Bicentennial Commemorative lecture.

A public lecture in the evening is a customary event on the Founder's day. This year the lecture was by the renowned biochemist and a pioneer in Indian biotechnology Govindarajan Padmanaban. Currently, he holds the NASI-Platinum Jubilee Chair/Honorary Professor at the Indian Institute of Science, Bengaluru. Professor Padmanaban spoke on "Growth of Biotechnology in India". He described the key initiatives of the Indian government in the early phase of the development of biotechnology in the early eighties, which led to the formation of the Department of Biotechnology (DBT) in 1986. He then spoke at length on the various initiatives and establishments that DBT supported through new institutions, support for research, creation of infrastructure, generation of human resources, formulation of regulatory regimes and linkage with industries. With brief descriptions of his own research in the areas of recombinant DNA technology, its applications, malarial parasite biology, identifying drug targets and development of vaccines for hepatitis B, Padmanaban gave an account of the growth of modern life sciences research in India. He then spoke on the new directions involving stem cell research and applications in the areas of Health and Agriculture and how India can contribute significantly. While acknowledging issues in Venture capital for new startups, he however saw optimism in the Indian government's support mechanisms through Technology Development Board (TDB) initiative. His closing part of the lecture focussed on the potential of India to reach global leadership in the areas of vaccines, bio- generics, traditional medicine (if properly validated and standardized) and service sector, including contract projects.

4.6.3 Vainu Bappu Memorial Lecture

James Binney giving the Vainu Bappu Memorial lecture on *What makes spiral galaxies tick?*

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

4.6.4 International Womens Day

The 8th March, 2011 was the centenary celebration of the International Womens Day worldwide, and also occurred in the International Year of Chemistry. IIA celebrated the occasion with a public lecture titled *In the Quest of Structure and Function: Dorothy Hodgkin, Scientist and Social Activist* by S. Chatterjee from IIA. Dorothy Crowfoot Hodgkin was awarded the 1964 Nobel Prize in chemistry for determining the structure of Vitamin B12 and peni-

cillin, and was also a scientist who was deeply concerned about building scientific institutions and resisting structures of oppression. Deepak Srinivasan, faculty from the Srishti School of Art, Design and Technology was the respondent at the event. The event was attended by a large cross section of people both from within and outside IIA. The discussion that followed covered a wide range of issues including history of science, the social context of science, Hodgkin's visit to India, and the long-term impact of her discoveries, and served as a trigger for regular informal discussions through the months that followed on a rich variety of topics, especially by students.

Special Lectures

8 March 2011
Sabyasachi Chatterjee
IIA, Bangalore
In the Quest of Structure and Function
Dorothy Hodgkin: Scientist and Social Activist

3 February 2011
Roddam Narasimha
Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore
The Hydrodynamics of Cumulus Clouds

2 February 2011
Hans Meinhardt
Max Planck Institute for Developmental Biology Tubingen, Germany
Pattern Formation in Biology: Local Self-Enhancement and Long-Ranging Inhibition as the Driving Force

16 April 2010
Andre Beteille
Delhi University, New Delhi
Can Rights Undermine Trust ? How Institutions Work and Why they Fail

Colloquia

29 March 2011
S. Sridhar
Raman Research Institute, Bangalore
Interstellar, Interplanetary and MHD Turbulence

1 March 2011
D. Sen
Centre for High Energy Physics, IISc
Quantum Games

15 February 2011
Wei-Tou Ni
National Tsing Hua University, Taiwan
Probing the Co-Evolution of Galaxies with Black Holes via Space Gravitational-Wave Detection

25 January 2011
David Buckley
SALT, South Africa
Science with SALT

18 January 2011
N. Udaya Shankar
Raman Research Institute
A Southern Sky Survey at 150 MHz Using the Mauritius Radio Telescope

4 January 2011
Indranil Chattopadhyay
ARIES, Nainital
Effect of Plasma Composition on Black Hole Accretion Disc Solutions

21 December 2010
Ramarao Tata
Instituto de Astrofisica de Canarias, Spain
A Multi-Wavelength Survey of the Young Open Cluster NGC6823

14 December 2010
Frank Hill
National Solar Observatory, USA
Helioseismic Observations of Solar Convection Zone Dynamics and their Relationship to Solar Activity

23 November 2010
P. R. Vishwanath
IIA, Bangalore
High Energy Sky: Progress in Gamma Ray Astronomy

5 October 2010
T. N. Rengarajan
TIFR, Mumbai
Understanding the Radio-Far-Infrared Correlation in Galaxies

28 September 2010
Viktor Fedun
University of Sheffield, UK
3D Numerical Simulations of Torsional Alfven Waves

7 September 2010
Arnab Rai Choudhuri
IISc, Bangalore
Can We Predict Sunspot Cycles ?

31 August 2010
G. Vigeesh
IIA, Bangalore
Structure, Dynamics and Heating in Magnetized Regions of Solar Atmosphere

17 August 2010
Blesson Mathew
IIA, Bangalore
Study of Emission Line Stars in Young Open Clusters

3 August 2010
A. Arellano Ferro
Instituto de Astronoma, Universidad Nacional Autnoma de Mxico
CCD Photometry of Globular Clusters: the Ongoing Program

13 July 2010
Stuart Jefferies
Institute for Astronomy, University of Hawaii
Observing the Sun from the Geographic South Pole

22 June 2010
Kiran Jain
National Solar Observatory, Tucson, USA
GONG and MDI Observations Over a Solar Cycle

1 June 2010
Chiranjib Konar
IIA, Bangalore
Radio Galaxies and their Dynamics

25 May 2010
N. Mukunda
IISC, Bangalore 560 012
The Three Roles of Symmetry in Fundamental Physics

13 April 2010
Jean-Claude Vial
Institut d'Astrophysique Spatiale, Orsay, France
New French Programmes in Space Instrumentation for Solar Research

Seminars

28 March 2011
Phani Murali Krishna R
Indian Institute of Tropical Meteorology, Pune
High Performance Computing (HPC) and its Applications in Atmospheric Sciences and Physics

28 March 2011
Priyam Das
IISER, Kolkata
Investigation of Various Nonlinear Excitations of Bose-Einstein Condensates

18 March 2011
John Hutchings
Herzberg Institute of Astrophysics, Victoria, Canada
Isolating QSO Types with the Combined GALEX-SDSS Database

16 March 2011
John Hutchings
Herzberg Institute of Astrophysics, Victoria, Canada
An Overview of Plans to Upgrade the CFHT to 10m

8 March 2011
Rajesh Gopal
Bose Institute, Kolkata
Magnetic Field Effects in Galaxy Clusters

17 February 2011
Vijay Kapur
IGNOU, New Delhi
The Role of the Administrative Bureaucracy in Promoting Technology and Scientific Research - A Reality Check in the Indian Context

10 February 2011
N. Kameswara Rao, IIA
Buckyballs Bounce to R Coronae Borealis Stars

1 February 2011
Almudena Alonso-Herrero
Centro de Astrobiologia, INTA-CSIC, Madrid, Spain
Testing the Unified Model of AGN: Fitting the IR Emission of Seyfert

28 January 2011
Shravan Hanasoge
Princeton University, Princeton, USA
Seismic Constraints on Global Solar Convection

27 January 2011
G. Thejappa
University of Maryland & NASA/GSFC, USA
Some Recent Results from STEREO

24 January 2011
S. Turck-Chieze
IRFU, CEA, France
A Global View of the Solar Magnetism

24 January 2011
Donald M. Hassler
Southwest Research Institute, Colorado, USA
Spectral Imaging of the Coronal Environment (SPICE) on the Solar Orbiter Mission

10 January 2011
Shrinivas Kulkarni
California Institute of Technology, USA
Next Generation Transient Facility

7 January 2011
H. Frisch
Observatoire de la Cote d'Azur, Nice, France
The Hanle Effect: (i) Action of a Random Markovian Magnetic Field, (ii) A Scattering Expansion Method of Solution

3 January 2011
Masayuki Yamanaka
Hiroshima University
Observational Study of the Extremely Luminous Type Ia SN 2009dc

30 December 2010
Nozomu Tominaga
Konan University, Japan
Shock Breakouts of Type II Plateau Supernovae and Future Survey Plans

16 December 2010
Poonam Chandra
Royal Military College, Canada
Cosmological transient objects

15 December 2010
G. Sindhuja, IIA
Temporal variations in the Solar chromosphere-Ca K line profiles

14 December 2010
S. Sumangala Rao, IIA
Chemical Compositions of a sample of post-AGB stars

2 December 2010
P. K. Mukherjee
Ramakrishna Mission Vivekananda University & Visva Bharati, Santiniketan, West Bengal
Spectroscopy of Atoms under Liquid Helium

25 November 2010
Ram Ajor Maurya
Udaipur Solar Observatory, Physical Research Laboratory, Ahmedabad
Seismic Study of Solar Active Regions Using Ring Diagrams

28 October 2010
Rohan Eugene Louis
Udaipur Solar Observatory
Achieving High Spatial Resolution Using Adaptive Optics at the Udaipur Solar Observatory

28 October 2010
P. Ramya, IIA
Study of Stellar Streams in the Galaxy

22 October 2010
Neeharika Sinha, IIA
An Implication of Recent Prolonged Solar Minimum through Almahata Sitta Meteorite Fall

7 October 2010
Dharam Vir Lal
Harvard-Smithsonian Center for Astrophysics, USA
Constraining the Nature of X-shaped Radio Galaxies - New Insights from Radio and X-ray Data

4 October 2010
B. P. Hema, IIA
Clues to the Origin of RCB Stars

4 October 2010
G. Indu, IIA
Recent Star Formation History of the Magellanic Clouds

2 September 2010
Arya Dhar, IIA
Novel Quantum Phases in Ultracold Atoms in Optical Superlattices

30 August 2010
Prashanth Mohan, IIA
Models for Observational Signatures of Black Holes

26 August 2010
Jayesh Bhatt
Brunel University, UK
Molecular Simulations and Internal dynamical properties of particulate systems

19 August 2010
K. B. Ramesh, IIA
Coronal Activity and Sunspots – Solar Cycle Perspective

30 July 2010
Paul J. Wiita
The College of New Jersey, USA
Testing Active Galactic Nuclei Unification via Quasar Optical Spectra and Radio Morphologies

29 July 2010
Alok C. Gupta
ARIES, Nainital
Quasi Periodic Oscillations (QPOs) in Blazars on Diverse Timescales

28 July 2010
Gordon MacDonald
University of California, Northridge, USA
Studies of Waves in Sunspots Using Spectropolarimetric and Imaging Observations

28 July 2010
Kristopher Vorren
University of North Carolina, USA
Probing of Solar Core Rotation

28 July 2010
Megan Force
University of Vermont, USA
Infrared and Optical Observations of R Corona Borealis Stars

28 July 2010 Christene Lynch
University of Iowa, USA
Optical Photometry and Spectroscopy of SN 2006be, a Type IIP Supernova

23 July 2010
Noah Brosch
Tel Aviv University, Israel
The Fascinating World of Ring Galaxies

13 July 2010
M. B. Roopashree, IIA
Multilayered Temporally Evolving Phase Screens Based on Statistical Interpolation

8 July 2010
Jean-Pierre Rozelot
Nice University, France
A Story of the solar oblateness: from Princeton, 1966 to future space missions

6 July 2010
Bharat Kumar Yerra, IIA
Survey for Li-rich K giants

1 July 2010
Georgeta Maris
Institute of Geodynamics of the Romanian Academy, Romania
Specific Features of the High Speed Streams in Solar Wind during Solar Cycle 23

1 July 2010
Mansi Kasliwal
California Institute of Technology, USA
The Palomar Transient Factory

30 June 2010
Megan Force
University of Vermont, USA
Subpulse Modulation and Moding of the Five-Component Pulsar B1737+13

30 June 2010
Kristopher Vorren
University of North Carolina at Chapel Hill, USA
Carolina Physics

29 June 2010
Lakshmi Pradeep Chitta, IIA
Oscillations and heating of the Solar Chromosphere at the sites of fine scale features as seen with Hinode/SOT and SoHO/MDI

29 June 2010
H. N. Smitha, IIA
Analysis of the Polarimetric Data of Ca 4227 line

28 June 2010
Gordon MacDonald
California State University, Northridge, USA
Flows in the Magnetized Regions near Sunspots

28 June 2010
Christene Lynch

University of Iowa, Iowa City, Iowa, USA
First Calculationa of Growth Rates for Saturn Kilometric Radiation as Measured by Cassini

24 June 2010
C. S. Stalin, IIA
Quasars in the Canada-France-Hawaii Telescope Legacy Survey

22 June 2010
A. Vyas, IIA
Thresholded Zernike Reconstructor and Dither Based Sensor towards Improved Wavefront Reconstruction in Adaptive Optics Systems

18 June 2010
Sundar Srinivasan
Institut d'Astrophysique de Paris, France
The GRAMS AGB Models: Calculating the Mass-Loss Return to the LMC from SED fits to SAGE Data

3 June 2010
Sumedh V. Anathpindika, IIA
A Numerical Investigation into the Formation of prestellar Cores

25 May 2010
A. C. Pradhan, IIA
Far Ultraviolet Diffuse Emission from the Large Magellanic Cloud

18 May 2010
Rumpa Choudhury, IIA
Variable Circumstellar Activities of Herbig Ae Star HD 38238

17 May 2010
Pravabati Chingangbam
Sejong University, South Korea
Search for primordial non-Gaussian signals in the CMB

Special Lectures

16 February 2011
Jim Burge
University of Arizona,USA
Mirror Technology for the Giant Magellan Telescope

13 January 2011
Arthur I. Miller
University College, London, UK
Empire of the Stars: Friendship, Obsession and Betrayal in the Quest for Black Holes

11 January 2011
Ambrogio Fasoli
Ecole Polytechnique Federal of Lausanne, Switzerland
Plasma Physics for Magnetic Fusion Research

12 October 2010
C. Sivaram, IIA
2010 Physics Nobel Prize

17 September 2010
Seyed E.Hasnain
Central University of Hyderabad, Hyderabad
Tuberculosis: The Vicious Triangle of Pathogen, Host and Environment Continues to pose a challenge to Science

17 September 2010
Dirk Soltau
Kiepenheuer-Institut fur Sonnenphysik, Freiburg, Germany
Looking into the fire The future of solar observation

10 August 2010
Govindarajan Padmanaban
Indian Institute of Science, Bangalore
Growth of Biotechnology in India

Chapter 5

Outreach Activities

5.1 Founder's Day at Kavalur

Vainu Bappu Observatory, Kavalur also celebrated the Founder's Day. D. C. V.Mallik from IIA, Bangalore presided over as the chief guest and garlanded Professor Bappu's photo. On this occasion, a special public outreach programme was organized for college students. Welcome address was given by C. Muthumariappan the Scientist-in-charge at VBO, Kavalur. A total of 72 students from six colleges (10 physics students and 2 lecturers from each college) participated. D. C. V. Mallik delivered a lecture on "The World Beyond Ours" to the audience. This was followed by inter-collegeate quiz competition on Physics and Astronomy conducted by C. Muthumariappan. Saradha College for Women, Salem, won the first prize and Govt College for Men, Thiruvannamalai won the second prize of the quiz competition, and prizes were distributed to them by D. C. V. Mallik.

D. C. V. Mallik presenting a memento to the winner of the Science and Astronomy Quiz, from the Sharada College for Women, Salem

Following the programme, a visit to the Observatory was organized and the facilities were introduced to the students.The programme generated a great deal of interest in Astronomy among the students in Astronomy and led to discussion on various topics in Astronomy. The concluding remarks and vote of thanks were given by C. Muthumariappan.

The 1st workshop on *Understanding Satellites* for children from Government High School, Madivaala, at their school. A student builds a satellite model that he has designed with newspaper.


The 2nd workshop on *Understanding Satellites* at IIA for children from Government High School, Madivaala. *left:* B. Ravindra (IIA) discusses satellites with the students and teachers. *right:* Children imagine and picturise exploration with satellites.

5.2 Extension Programme at a Neighbourhood School

IIA's extension programme with its neighbourhood school acquired new dimensions in the past year. In 2008, preparatory to the International Year of Astronomy, IIA had initiated an extension programme with the Government High School, Madivaala, which is located in the neighbourhood of IIA. In the past year, apart from regular participation by the students from the school in IIA's Science Day celebrations, sky-watching and popular lectures, about 30 children from the school were involved in an exploration of space craft and satellites, using several workshops and a visit to ISRO. The workshops were designed by the Srishti School of Art, Design and Technology and took place both at the school and at IIA. The workshops involved face-to-face discussions with scientists, art and craft, and theatre, wherein the children were driven to explore their imagination and design satellite models. At the workshop at IIA, Jayant Murthy and B. Ravindra discussed astronomy from satellites.

This activity was then linked up with the astronomy festival Kalpaneya Yatre (see below) where the final workshop for the children was held, and scaled-up versions of their models that they designed were fabricated in bamboo and paper by crafts people and became lanterns in the festival, to which were added the childrens own papier mache lanterns. The children then participated in a beautiful lantern procession at dusk at the festival. In addition to the above *Understanding Satellites* project for the 30 children of the school, IIA facilitated the transport of 200 children from the school to participate in Kalpaneya Yatre.

(Prajval Shastri)

5.3 Kalpaneya Yatre

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

Christened Kalpaneya Yatre or Journey of Imagination, this festival was unique in several ways. Firstly, it was the first time that multiple institutions came together to organise an astronomy event for the public in Bangalore. Secondly, it was an interdisciplinary event with artist-designers from the Srishti School involved right from the beginning in the conception, design and implementation of the festival. Thirdly, the festival provided a space where the amateur astronomers and science popularisers of Bangalore joined hands with the astrophysicists and the artist-designers, to create a rich multi-dimensional experience for the public. The expanded partnership of the festival thus included the Bharat Gyan Vigyan

Vishwanath Palahalli gave a lecture *Yaaminiya Yaatrikaru* (*Travellers of the Night* in Kannada) at the Kalpaneya Yatre astronomy festival.

Prajval Shastri, Satya Narayana and Faseehana Saleem from IIA at one of the *Ask an Astronomer* sessions at Kalpaneya Yatre, discussing black holes.

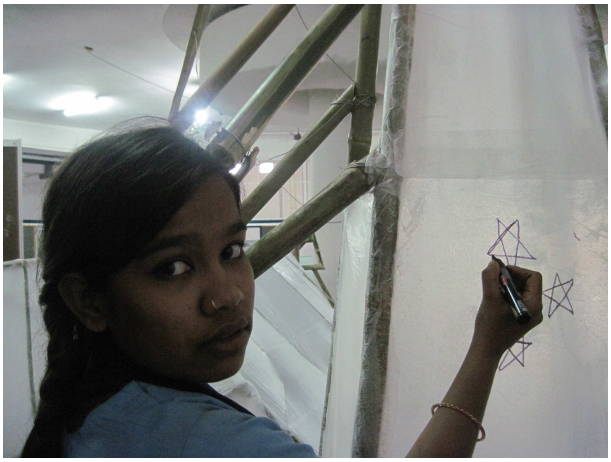
Samithi, Bangalore Astronomical Society, Association of Bangalore Amateur Astronomers, Navnirmiti (Mumbai), Vigyan Prasar (Delhi), Experimenta Film Society, Karnataka Rajya Vijnana Parishat, the JNP Club and Dynam Creativity Programmes.

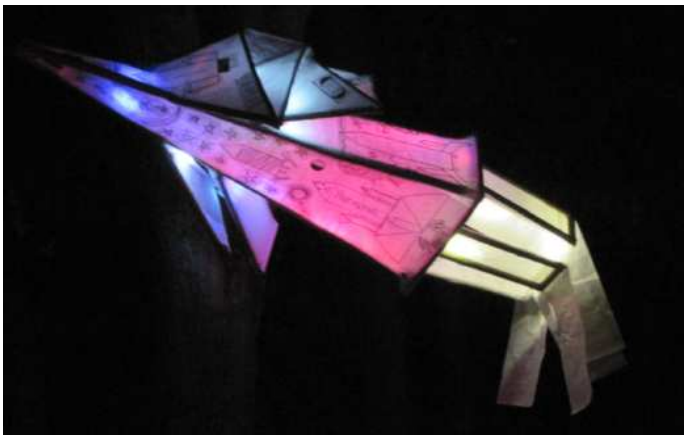
Sumedh V. Anathpindika and Firoza Sutaria at an *Ask an Astronomer* sessions at Kalpaneya Yatre, discussing the pitfalls of astrology.

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

The festival was aimed at people aged 10 and above of all backgrounds. In order to encourage the widest possible participation, only a nominal fee was charged for adults and children had free entry. A highlight of the festival were the astronomy activity workshops that were conducted for students. These workshops were mostly designed by Navnirmiti (Mumbai), Vigyan Prasar and Bharat Gyan Vigyan Samithi, and about thirty children of middle- and high-school levels participated in each workshop learnt about astronomy, sun-viewing, making simple devices for astronomy observations, understanding Jantar Mantar, etc. A total of 950 students participated in these workshops that occurred every day during the festival. The workshops were mostly bilingual. Volunteers from different parts of the state who were trained as resource persons in a pre-festival workshop conducted by Navnirmiti (Mumbai) conducted and assisted these workshops. A resource base was thus created wherein these workshops can be replicated in the home regions of these volunteers. In addition, there was also a telescope-making workshop designed by Navnirmiti (Mumbai) for school teachers, in which a total of about 80 teachers made a low-cost telescope from a kit, which they could then take back for use in their schools.

The festival had several lectures by eminent astrophysicists, including three from IIA. Vishwanath Palahalli spoke in Kannada on *Travellers of the Night*





Bamboo lanterns were made by crafts people at the Kalpaneya Yatre based on the newspaper models of satellites designed by Madivaala school students in the *Understanding Satellites* project. *left:* A student paints on the 'satellite lantern'. *right:* a 'satellite lantern' on display at Kalpaneya Yatre.

(Yaaminiya Yaatrikaru), Firoza Sutaria spoke on *Cauldrons of Creation: How stars live and die*, and Jayant Murthy spoke on *Hrithik, 8-legged freaks from space, and us: The search for life in the cosmos.* A very popular feature of the festival was the face-to-face interactions between the public and scientists organised by IIA, involving over 50 volunteers from among astrophysicists, technical staff and students from the various research institutes of Bangalore. Over 25 astrophysicists from IIA participated in these *Ask an Astronomer* web-cameras, the public was brought into audio-visual contact with scientists working at the telescopes in different observatories of the country, including IIA's Vainu Bappu Observatory, Kavalur and the Indian Astronomical Observatory, Hanle. The public, and especially students had exciting conversations with the scientists at the telescopes in these sessions. Amateur astronomers of the Bangalore Astronomical Society, IIA's partners in outreach activities through the International Year of Astronomy, co-ordinated several sky-watching sessions in the evenings using their telescopes, including a 17 inch telescope. A multi-media interactive theatre presentation entitled 'Unscientific Storytelling' designed by Srishti, which explored the role of imagination and individual world views in science education and practice, was performed on three of the festival days, and several scientists from IIA participated as the interactive audience.

The students of Government High School, Madivaala, with whom IIA has had an extension programme since 2008, participated in a two-month long project on 'Understanding Satellites', leading up to the festival. This project, designed by the Srishti

Ravinder Banyal from IIA making a point at the interdisciplinary Symposium on *Public Ownership of Science*, at Kalpaneya Yatre.

School in collaboration with IIA and ISAC, had about 30 children participate in several pre-festival workshops including at IIA, and visit ISAC to see the satellite models. These activities were meant to trigger the imagination of the children to design satellite models, and culminated in a parade of satellite lanterns that the children made during the festival. In addition, about 200 children from the school were funded by IIA to spend a day at the festival to view the exhibition, participate in the student workshops, lectures and Ask-an-Astronomer sessions.

A major highlight of the festival was an interdisciplinary all-day symposium on the final day organised by Prajval Shastri, Meena Vari (Srishti School) and Neeruj Mohan (J.N. Planetarium). The symposium,

titled *Astronomy & Society: Public Ownership of Science* had speakers, respondents and participants from a wide variety of backgrounds, and included astrophysicists, social scientists, artist-designers, amateur astronomers, science popularisers, educators, facilitators, and members of the public, and there were very lively debates on the nature of the inspiration that astronomy is, astronomy as a vehicle for scientific literacy, rationality and the social responsibility of astrophysicists, and the disciplinary and cultural barriers to growth of the spirit of discovery. About ten astrophysicists from IIA participated in the symposium.

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

(Prajval Shastri, IIA co-ordinator for Kalpaneya Yatre*)*

5.4 National Science Day

A painting competition for school children on National Science Day at IIA.

National Science Day (28th February) which commemorates the discovery of Raman Effect in 1928, by the Indian physicist Sir C. V. Raman, was coordinated this year at IIA by E. Ebenezer. The celebrations were marked by several fun-filled activities for children, a science quiz, painting competition, talks, sun viewing, movies, exhibits, colourful poster sessions, etc. There were also exciting hands-on experiments in physics and chemistry to understand physical laws that govern our universe. Over 200 high school children from different schools in Koramangala and the adjoining areas, including the Government High School Madivaala with which IIA has an extension programme participated in this annual event.

K. B. Ramesh eloquently explained many fascinating and interesting features of our nearest star, the Sun. He also blended his talk with stunning visuals of solar flares, magnetic storms, coronal mass ejections and sunspots to show that sun is a highly dynamic object and the events that happen on its surface have direct bearing on the terrestrial life. Last decade was particularly exciting for the Indian space programme, with the success of Chandrayaan-1 mission to the Moon has captured the imagination of many young people all over the country. Jayant Murthy spoke on *Science from Space*. He described the importance of doing science from space and various scientific missions that are in progress, both in India and abroad.

The year 2011 is also celebrated as an international year of chemistry (IYC 2011) all over the world. S. Chatterjee gave a talk entitled, *Discovery of Helium: Astronomy's gift to chemistry.* He highlighted the fact that Helium, known to be the second most abundant element in the universe, was first observed in the solar spectrum by a French astrophysicist Pierre Jules Janssen on 18th August 1868 during a total solar eclipse in Guntur (Andhra Pradesh, India). C. Sivaram, also well known for his popular talks and science writings, gave a lecture on *The Frontiers in Astronomy.* The lecture covered the vast areas of research in astronomy.

Subsequently, E. Ebenezer organised a painting competition and Pradeep Chitta organized an astronomy and science quiz. Individual prizes for both these events were also given to the respective winners.

Ravinder Banyal and B. Ravindra setup some exciting experiments that students could try for themselves. Many students were first amazed and thought it as some kind of magic before the proper explanation was given. Experiments to explain, the concepts of mechanics, electrostatics, laws fluids, properties of fundamental particles, were set up. J. P. Lancelot and his team showed the optical experiments done at the photonics division. Students also enjoyed posters sessions covering a variety of themes which showcased existing and future observational facilities of the institute, a colorful depiction of our solar system, Sun, Space Weather, Solar Terrestrial relationships, meteorites, neutron stars and fundamental particles. The models of HCT & Aditya set

R. Banyal and B. Ravindra explaining a point to the students, National Science Day at IIA.

N. Sivaraj explaining the technical aspects involved in the telescope drive mechanisms, Science Day at IIA.

up by Murali Das attracted children. Also on display were models of our major telescopes and posters and a model were explained by the team of NLST volunteers. The poster session was a success because of the large number of scientists who participated, including Neeharika Sinha, N. Vasantharaju, Sangita K. Padhy, Rajendra B. Singh, K. Anjali John, and Ramkumar Prabhu, Dinesh Kumar and Vaidehi.

Volunteers of the IIA Electronics lab led by N. Sivaraj, K. Anupama & Janaki Ram, explained to the students the technical aspects involved in the telescope movements, various types of motors and drives used in the RA and Dec axis and RA tracking. They were also explained about the Coelostat drive required for Solar image tracking during the total Solar Eclipse experiments, Micro stepping drive system – its advantages, applications, resolution, accuracy and Rotary stages for positioning. The students were explained about the CCD systems, used in the field of astronomy, the current advances in the imaging systems and performance of detectors.

S. Chatterjee taking questions after his lecture on *The Discovery of Helium: Astronomy's Gift to Chemistry*, Science Day at IIA.

In the evening, Ashok Pati delivered a public lecture titled *A Preface to Exploring the Universe*. Apart from introducing various objects in the night sky using virtual Planetarium - Stellarium, the speaker also took the audience on a fascinating journey of the solar system to the stellar denizens of the Milky Way and the far flung galaxies in the Universe.

The concluding event of the day was the night sky

watch programme for the general public that was coordinated by Edwin Ebenezer, K. Kuppuswamy, Ravinder Banyal, Prajval Shastri, S. Chatterjee and Padmakar Singh Parihar. Volunteers from the Bangalore Astronomical Society, who have partnered with IIA in astronomy outreach since the International Year of Astronomy also participated, as did several students from IIA. A 14-inch Meade telescope and a 3-inch Galileoscope were set up for viewing the night sky. About 80 enthusiastic sky watchers participated, both in the observations and discussions on astronomy and other science topics. Some stayed late into night with Amar Sharma, Naveen and Santhosh, all from BAS, to gaze at the stars and constellations.

Overall, the students and supporting staff of IIA played a key role to make the Science Day a great success.

(Ravinder Banyal & E. Ebenezer)

5.5 Indian Science Congress

IIA displayed exhibits and participated in *Pride of India - Frontier Science & Technologies Mega Expo* at the 98th Indian science congress, held at SRM University, Chennai from 1st - 7th January, 2011. The stall was set up to showcase facilities and achievements of IIA in the field of Astronomy & Astrophysics. Models were put up to illustrate the 2-M HCT telescope and its operation. A miniature model of the 2.34 Vainu Bappu Telescope (VBT) was also put up. Audio-video shows of short films on various topics on Astronomy & Astrophysics, were also organized and there were in great demand. Approximately more than 50,000 students from nearby schools & colleges and other institutions and congress delegates visited the exhibition. B. C. Bhatt along with T. K. Muralidas and S. Pukalenthi of VBO were responsible for setting up the stall at the venue.

(B. C. Bhatt & team)

5.6 Exhibition at University of Mysore

IIA participated in the 3rd Conference-cum-Exhibition held by the Science & Technology Academy, Government of Karnataka, on the occasion of the Golden Jubilee of the University of Mysore campus, Manasagangotri, Mysore, held during 15 – 16 February 2011. The theme of the event was "Globalization: Challenges & Opportunities for Science & Technology"

A Large number of institutions including ISRO and Nehru Planetarium, Bangalore participated. The exhibition stall presented by IIA, which comprised of posters, models, and a video show, was visited by hundreds of students and teachers from various University departments and colleges in around Mysore. The posters highlighted various areas of research at IIA, at a popular level and also presented details of the graduate study programmes at IIA.

(S. P. Bagare, B. C. Bhatt, M. B. Roopashree, A. Vyas & T. K. Murali Das)

(From left) S. Pukalenthi of VBO, Kavalur, K. Sundara Raman of Kodaikanal Observatory, S. K. Saha IIA, Bangalore and B. C. Bhatt of CREST, Hosakote at the 98th Indian science Congress at Chennai.

B. C. Bhatt discussing a point with students and public.

S. P. Bagare and A. Vyas from IIA are seen interacting with a student.

5.7 Popular Lectures, Radio Talks & Interviews

R. Banyal gave the following popular lectures: *Astrology and Astronomy,* Himachal Gyan Vigyan Samiti, Mandi 22nd - 24th October, 2010. *Telescope: A Window to the Fascinating Universe,* MS Ramaiah School on 9th February, 2011.

S. Chatterjee gave the following popular lectures: *Meghnad Saha: Scientist and Crusader*, on the 8th September, 2010, at the Sundarayya Vignan Kendram , Hyderabad; *Discovery of Helium: Astronomy's gift to chemistry*, on the 28th February, 2011, National Science Day, at both IIA and Lakshmi Ammani College, Malleswaram, Bangalore; *In the quest of structure and function: Dorothy Hodgkin-scientist and social activist*, lecture delivered at IIA on 8th March, 2011 at the celebration of the Centenary of the International Womens Day.

Siraj Hasan gave a popular lecture on *The Dynamic Sun* at the Nobel Laureates' Science Conclave at IIT, Allahabad, 14 December, 2010.

K. M. Hiremath gave a popular lecture on *The Sun* at the IIA auditorium, on 5th December, 2010 during the visit of the students from Raja Rajeshwari Engineering college, Bengaluru.

J. Murthy gave a talk titled *Space Astronomy* at BIFR, Bangalore on 21st May, 2010; *Space Astronomy* at Planetarium, Bangalore on 1st June, 2010; *Research Methodology* at Christ University, Bangalore, on 21st September 2010; *Interstellar Medium* at BIFR, 25th September, 2010; *Astronomy with Archives* at Sudarshan Vidya Mandir, Bangalore on 20th November 2010; *Hrithik, 8-Legged Freaks and You* at Planetarium, Bangalore, 4th December, 2010 *Space Astronomy* at BIFR, Bangalore 16th April 2011.

A. K. Pati gave two talks, *Exploring Astronomy - The Solar System*, and *Exploring Astronomy - Stars and our Galaxy*, in the DST - INSPIRE programme for school students at KIIT university, Bhubaneswar, on 15th January, 2011.

T. P. Prabhu gave a popular lecture *Galaxies,* Taralaya, Bangalore, 4th June, 2010; *Observational Facilities in India,* MPBIFR, Bangalore, 20th November, 2010.

M. Safonova gave a popular talk on *Astronomical Myths about 2012 Doomsday*, at the Nightingales Elders Day Care Centre, Malleswaram, Bangalore, on April 8, 2011.

A. K. Saxena gave a talk on *Important Astronomical Discoveries and its Impact on Mankind* at the *Discussion Meeting at Dr.Raja Ramanna Children's Science Club* on Septemebr 25, 2010 and at the Dignity Foundation, on 16th December, 2010. He gave a popular talk on astronomy in Hindi titled *Brahmand Ki Ek Yatra* at ISRO on February 28, 2011 where he was the Chief guest.

P. Shastri gave the following popular talks: *Galaxies and their Growing Black Holes*, J.N. Planetarium, Bangalore, 2 June, 2010; *Namma Mohaka Vishva - Our Enchanting Universe*, a bi-lingual lecture in Kannada and English on the 14th July, 2010, at the Vishveshwarayya Industrial and Technological Museum, Bangalore, also broadcast via EduSAT to Government High School, Karjagi, Haveri, Karnataka; lectures in Kannada titled *Namma Mohaka Vishva*, at the VIDYAARTHI-VIJNAANI NERA SAMVAADA programme of the Karnataka Rajya Vijnana Parishat, for school children from the Ramanagara District, on the 30th January, 2011, at Magadi, and for children from the Bangalore Urban District on the 31st January, 2011, at Cubbon Park, Bangalore; *Growing Black Holes in the Middles of Galaxies*, at Parikrama School, 24th February, 2011.

C. S. Stalin gave a talk on "Explosions in the Sky" in BNMIT College, Bangalore on 5th May, 2010. He also gave two lectures on AGN at a workshop on Astronomy in Providence Women's college, Calicut

conducted by Calicut University, Calicut, Kerala and at IUCAA, Pune, during 7th – 9th September, 2010.

K. Sundara Raman gave the following lectures: on 17th - 18th February, 2011 in KSR College of Technology, Tiruchengode, near Erode Valedictory address on 18th February, 2011. Two lectures at the birth anniversay celebrations of Vainu Bappu and Vikram Sarabhai by the Tamil Nadu Science Centre & Planetarium, Trichy, titled *Indian Scientists and their valuable contributions in the field of Astrophysics and Space Science* and *Avenues in fundamental sciences*; *Astrophysics and studies on the Sun*, at the Velalar College of Engineering and Technology, Erode on 20th October, 2010; *The Sun and its impact on the Earth* at Gandhigram Rural University, Dindigul, 28th January 2011; Inaugural address titled *The Importance of Science Exhibitions*, at the Science Exhibition, St. Peter's Higher Secondary School, Kodaikanal on 4th February, 2011.

Firoza Sutaria gave a popular lecture on *Cauldrons of Creation: How stars live and die* at the KALPANEYA YATRE astronomy festival, 28th November, 2010, and a lecture on *Stellar Evolution* at the Department of Physics, Meenakshi College for Women, Chennai, during national seminar on Astrophysics, 18th September, 2010.

P. R. Vishwanath gave the following popular lectures *Yaaminiya Yatrikaru (Kannada)*, Nehru Planetarium, 26th November, 2010; *Khagola* (Kannada) Government School, Hulimavu, 19th February, 2011.

5.8 Popular Books & Articles

R. Banyal published the following article titled *Climate Change and Global Warming* for Youth4Earth (2011) http://youth4earth.org/globalwarming.pdf

S. Chatterjee published the following popular articles: *Jagotik Ushnayan: Bijnan o Rajneeti (Global Warming: Science and Politics)* in Bengali, Special Issue of *Notun Chithi*, October, 2010; *Commentary: Science Education* in Social Scientist (2010), 38. 178.

R. C. Kapoor published the following articles in THE HAWK: *Comet McNaught (C/2009 R1): A View of a Lifetime,* 12th June, 2010; *The Perseids Meteors Shower Tonight! Aug 12/13, 2010* 12th Aug 2010; *Telescopic Discoveries of Asteroids from India*, 18th August 2010 (http://hdl.handle.net/2248/5232); *Deep Impacting the Comet - 103P/Hartley 2 on November 4, 2010,* 17th September, 2010.

M. Safonova published the following popular articles in the on-line journal NAUKA I TECHNOLOGIYI ROSSI: *Zamorozhennye zvesdy*, (*Frozen Stars* in Russian), 3 December, 2010, and *Spasaisya kto mozhet*, (*2012 Doomsday Mythology* in Russian), 31 December, 2010.

K. Sundara Raman Science Reporter, NISCAIR publ. CSIR, Vol. 47, No.11, pp.19-22, November 2010. *Dangerous Face of the Sun.*

P. R. Vishwanath published the article *Paapa, Pluto* in Kannda Prabha (February 2011); *Aakaashadalli atithi baraliddaneye?* Kannada Prabha, 27th March, 2011.

Chapter 6

Miscellaneous Activities by IIA Staff

6.1 Invited & Contributed Talks

G. C. Anupama gave the following invited talks: (1) Inaugural talk at "World Space Week" held at LPSC, ISRO, Trivandrum on 4th October, 2010; (2) *Follow-up Observations of Low Redshift Supernovae Using the 2m HCT* – seminar delivered at Caltech, Pasadena, USA on 24 November 2010; (3) Invited Review talk on *Observational Properties of Supernovae* at the Indo-Russian workshop on "Supernovae and GRB sources"; *Supernovae and Related Objects* – Invited talk presented at the "TMT Science and Instrumentation Workshop".

S. P. Bagare gave the Inaugural address on *Astrophysics Research in India* at the Workshop on "Recent Trends in Astrophysics", sponsored by the UGC (under DRS-SAP scheme) 28 March 2011, Mysore.

Ravinder Banyal gave an invited lecture on *Myths, Superstitions and Propaganda in the Scientific Age,* at the XIIIth All-India Peoples Science Congress, Thrissur, 27th-31st December, 2010.

B. C. Bhatt gave an invited talk titled *Venus Atmosphere in Near-IR from Ground-Based Telescopes* at the International workshop on "Advances in Planetary Atmosphere and Exploration", from 12th – 13th July, 2010 organized by Physical Research Laboratory (PRL), Ahmedabad.

H. C. Bhatt gave an invited talk titled *Disks around Young Stellar Objects* on 10th December, 2010 at the Chandrasekhar Centenary Conference, IIA, Bangalore.

C. Birdie gave an invited talk titled *Distance Learning in Science using "Open Access Contents" – Role of Special Libraries in India* during the 2nd International Conference of Asian Special Libraries held at Tokyo, Japan during 10 – 12 February, 2011.

S. Chatterjee gave an invited talk titled *Waves in random media: Rough surface scattering and astronomical seeing*, at the Physics Department, Shiraz University, Shiraz, Iran, on the 9th May, 2010.

V. Chitnis gave an invited talk on *Recent Results from HAGAR*, Theme meeting on "VHE Gamma-ray Astronomy", Mt Abu, on 28th March, 2011.

B. P. Das gave the following invited talks: (1) Tokyo Metropolitan University, Tokyo, Japan, 17 December 2010 on *General Aspects of Electric Dipole Moments of Atoms*; (2) Tohoku University, Sendai, Japan, 22 December 2010 on *General Aspects of Electric Dipole Moments of Atoms*; (3) Kyoto University, Kyoto, Japan, 27 December 2010 on *Quantum Phases of Ultracold Atoms in an Optical Superlattice.*

S. Giridhar gave an invited review talk on *Progress in the Study of Post-AGB Stars* at "29th ASI meeting" held at Raipur during 23rd – 25th February, 2011.

A. Goswami gave the following talks: *Determination and Modelling of Chemical Compositions of Metal-poor stars and Observational Constraints for Galactic chemical Evolution* at the DST Meeting at BARC, Trombay, Mumbai, 19th November, 2010; an Invited talk titled *CEMP Stars at High Galactic Latitude: Clues for early Galactic Chemical Evolution* at IUCAA, Pune, 19th October, 2010; Two talks on (i) *Stellar Structure and Evolution* and (ii) End State of Stars at the NECRD-IGNOU-IUCAA school on "Astronomy and Astrophysics", December 14th - 17th, 2010, Guwahati; Invited talk titled *Stellar Yields and Galactic Chemical Evolution* at the 29th ASI meeting held during February 23rd – 25th, 2011, at Raipur; Talk titled *Cosmic Chemistry* at the TMT-India sci-

ence meeting at Delhi, 13th March, 2011.

G. R. Gupta gave a seminar on *Propagating MHD waves in the polar coronal hole regions* at Max Planck Institute of Solar System Research, Lindau, Germany, 23rd February, 2011. Thesis Colloquium titled *On the Nature of Propagating MHD Waves in the Solar Atmosphere* at Indian Institute of Science, Bangalore, on 21st October, 2010.

Siraj Hasan gave the following talks: *Past and Future of Solar Physics in India* at the SERC school on Space Weather, on 20 April, 2010, at the Indian Institute of Geomagnetism, Mumbai; *Variable Emission Line Coronagraph on Aditya*, at the meeting Future Out-of-ecliptic and in situ observations of the Sun, 30 Nov. 2010, at the International Space Studies Institute, Bern, Switzerland; *Solar and Space Science in India* at the Space Climate Symposium, January 17–22, 2011, Goa; *Dynamical processes in the atmosphere of the Sun*, at the Humboldt Kolleg on Self-organized criticality: Dynamics of complex systems, February 2-5, 2011, IIA, Bangalore; *Beginning of Solar Research in India*, at the First Asia Pacific Solar Physics Meeting, March 21-24, 2011, IIA, Bangalore; *National Large Solar Telescope of India* at the First Asia Pacific Solar Physics Meeting, March 21-24, 2011, IIA, Bangalore.

K. M. Hiremath gave an invited talk titled *Solar and Astronomical Forcing on the Earth's Climate* at the Asia Oceania Geo-sciences Society (AOGS) 2010 meeting held at the Convention Centre at Hyderabad hosted by Indian Geophysical Union during 5th - 9th July, 2010. He also gave an invited talk titled *Magnetic Field Structure of Mercury* at the International workshop on "Advances in Planetary Atmosphere and Exploration", from 12th – 13th July, 2010 organized by Physical Research Laboratory (PRL), Ahmedabad.

A. Mangalam gave an invited talk on *Relaxed Configurations of Gravitating Systems*, on 5th February, 2011, in "Self Organized Criticality: Dynamics of Complex Systems", at the Humboldt Kolleg, at IIA, Bangalore from 2nd – 5th February 2011.

S. P. Rajaguru gave the following contributed talks on: *Helioseismic and Spectroscopic Evidences for Acoustic Wave Sources beneath a Sunspot Umbral Photosphere* at the AOGS 2010 Meeting held at Hyderabad, India during 5th – 10th July, 2010; *Magnetohydrostatic Equilibrium in Starspots: Dependences on Colour and Surface Gravity* at the IAU Symposium 273 "Physics of the Sun and Starspots" held at Ventura, CA USA during 22 – 26 August, 2010; *Helioseismic Tomography of Sunspots and Deeper Structures in the Convection Zone* at the 3rd India-China and 1st Asia-Pacific Meeting on Solar Physics, held at IIA, Bangalore during 21st – 26th March, 2010.

B. Ravindra gave the following contributed talks: *Spectro-Polarimetric Observations of the Flare-related Disappearance of a Penumbra-like Structure*, in 6th polarization workshop held at Haleakala Maui, Hawaii, between May 30th - June 4th, 2010; Presented a contributory talk on *Evolution of Magnetic Field Twist and Tilt in Active Region NOAA 10930* in AOGS meeting held at Hyderabad, between 5th – 9th July, 2010; Presented a contributory talk on *A Dual Fabry-Perot Based Narrow Band Imager For the National Large Solar Telescope*, in 1st Asia-Pacific Solar Physics Meeting, held at IIA between 21st – 24th March, 2011

B. E. Reddy gave a talk on *Chemical Evolution of the Galactic Disk* at TMT Science and Instrumentation Workshop, Victoria, Canada on March 28th – 2nd April, 2011.

M. Safonova gave the following talks: *The Quest for IMBHs in Globular Clusters* at the Sternberg Astronomical Institute, Moscow State University, Moscow, Russia, on June 2010; and on *In Search of IMBHs in Globular Clusters* at the IIA in-house meeting, April, 2010.

S. K. Saha gave the following invited talks: *Hypertelescope Imaging*, at the 98th Session of Indian Science Congress,held at Chennai, 1st – 7th January, 2011; *Image Processing of Stellar Objects by interferometry*, at the International Conference on Contemporary Trends in Optics and Opto-Electronics, during 17th – 19th January, 2011, at Trivandrum; *Optical Instrumentation for Telescopes: Interferometry with or without real-time corrections*, at the Symposium on "Advanced Measurement Techniques and Instrumentation" (SAMTI), organised by Bhabha Atomic Research Centre, Mumbai, during 2nd – 4th February, 2011

P. Shastri gave a talk titled *Challenges of Modern Empirical Astrophysics* in the 3rd IIA-PennState Astrostatistics School, VBO, IIA, Kavalur, on 19th July, 2010; an invited talk titled *Science Prac-*

tice and Science Communication - an Experiential Perspective at the Srishti School of Art, Design and Technology, Bangalore on the 29th July, 2010; a seminar titled *Active Galactic Nuclei: Empirical Tests using Rigorously Selected Samples*, at the Kavli Institute of Astoparticle Physics and Cosmology, Stanford University, USA, on the 21st September, 2010; an invited lecture on the 19th October, 2010 at the 21st annual international meeting of the Third World Academy of Sciences in Hyderabad, titled *Munching Black Holes and Growing Galaxies*; an invited lecture on the 26th November, 2010, titled *Gender Inequities in the Science Workplace: An Experiential Perspective* at the NIAS-DST Seminar on *Gender Issues in Indian Science: Transcending Barriers to Performance*; an invited talk on the 8th December, 2010, at the 11th international conference on Public Communication of Science & Technology, New Delhi, on *IIA's Activities in the International Year of Astronomy: Innovation in Approach and Maximising Reach*; an invited lecture in the opening plenary session of the XIIIth All-India Peoples Science Congress, Thrissur, on *Universalising the Universe: Astronomy as a Vehicle for Enhancing Public Interest in Science*, and another in the session on CHILDRENS FESTIVALS titled *Kalpaneya Yatre 2010: A 10-day inter-disciplinary Astronomy Festival.*

K. Sundara Raman delivered an invited talk titled "Solar Terrestrial Relations" on 6th January 2011 during the 98th Indian Science Congress conducted at SRM University, Chennai during 2-7 January 2011 in the Earth Science Section.

Veeresh Singh gave a talk titled *Seyfert Galaxies: Radio Continuum Properties and the Unification Scheme* on 2nd March, 2011 in a conference on "Diffuse Relativistic Plasmas" at RRI, Bangalore, India

P. R. Vishwanath gave invited talks titled *Interesting Results in Gamma Ray Astronomy, Crab nebula - the flares and the decline,* Theme meeting on gamma rays, Mt Abu, on 29th and 30th March 2010.

A. Vyas gave a talk in the SPIE symposium: Astronomical Telescopes and Instrumentation, San Diego, USA, 27 June - 2 July, 2010.
Dither-based sensor for improved consistency of adaptive optics system

6.2 Participation in Meetings

G. C. Anupama attended the following meetings: *Wideband X-ray Astronomy: Frontiers in Timing and Spectroscopy*, 13–16 January, 2011 at IUCAA, Pune; The ASI Meeting, 24–26 February, 2011, Raipur; *Indo-Russian workshop on Supernovae & GRB sources*, 1–4 March, 2011; ARIES, Nainital; *TMT Science and Instrumentation Workshop*, 28th – 30th March, 2010, Victoria, Canada.

L. S. Anusha participated in the "Chandrasekhar Centenary Conference", held during 7th – 11th December, 2010, at Indian Institute of Astrophysics, Bangalore, India.

S. P. Bagare participated in the following meetings: (1) IAU Symposium 273, 22nd - 26th August 2010, Ventura, USA and presented poster paper in session 1 on *Formation and Decay of Sunspots*;(2) Third Indo-China Workshop on Solar Physics and 1st Asia-Pacific Solar Physics Meeting, 21st - 24th March, 2011, Bangalore and Chaired Session XI on Solar Surface, *Active Regions and Magnetic Fields above them.* Presented two poster papers in session IV on *Observational Facilities and Instrumentation*; Workshop on Recent Trends in Astrophysics, sponsored by the UGC (under DRS-SAP scheme) 28 March 2011, Mysore and gave the Inaugural address on *Astrophysics Research in India.*

B. C. Bhatt attended the International workshop on *Advances in Planetary Atmosphere and Exploration*, from 12th – 13th July, 2010 organized by Physical Research Laboratory (PRL), Ahmedabad. gave an invited talk titled *Venus Atmosphere in Near-IR from Ground-Based Telescopes.*

B. C. Bhatt participated in the 7th Annual Meeting of Asia Oceania Geo-sciences Society (AOGS) organized at International Convention Centre, Hyderabad, hosted by Indian Geophysical Union during 5th - 9th July, 2010 and presented a paper on *Venus Observations from 2-M HCT, IAO-Hanle (Ladakh)* co-authored by T. P. Prabhu and S. Limaye.

S. Chatterjee participated in the 9th Iranian Medical Physics Conference, Tehran, May 19-20, 2010 (contributed talk titled *On the dependence of the x-ray attenuation coefficient of mixtures on the electron density and effective atomic number* presented by collaborator; and in the Eighth NIAS-DST training Programme on *Knowledge Management*, held at

NIAS, Bangalore, 26 July-7 August, 2010; participated in the XIIIth All-India Peoples Science Congress, Thrissur, in which he gave a talk on *Keeping the Dialogue Going* and organised the session on *Science Communication*.

R. T. Gangadhara participated in the "Chandrasekhar Centenary Conference", held during 7th – 11th December, 2010, at Indian Institute of Astrophysics, Bangalore, India and in the "Humboldt Kollegs Regional and expert Conference" held between 2nd - 5th February 2011, IIA, Bangalore.

A. Goswami has participated in the following meetings: "29th ASI Meeting", 23rd – 25th February, 2011, at Raipur, India and gave an invited talk on *Stellar Yields and Galactic Chemical Evolution*; "TMT-India science meeting" at Delhi, India, 13th March, 2011 and gave a talk on "Cosmic chemistry"; NECRD-IGNOU-IUCAA school on "Astronomy and Astrophysics", December 14th – 17th, 2010, Guwahati and gave two talks on (i) *Stellar Structure and Evolution* and (ii) *End State of Stars*

S. Giridhar attended the 29th ASI meeting held at Raipur during 23rd - 25th February, 2011 and gave an invited review talk on *Progress in the Study of Post-AGB Stars*.

G. R. Gupta attended the following meetings (1) "1st Asia-Pacific Solar Physics meeting, 21st – 24th March 2011", Indian Institute of Astrophysics, Bangalore and gave an Oral presentation *Presence of torsional Alfvén waves in polar coronal hole regions*; "Space Climate Symposium 4", 16th – 21st January, 2011, Goa and presented a poster titled *On the nature of propagating MHD waves in polar coronal holes*; "13th Young Astronomer's Meeting", 3rd – 5th September, 2010, Physical Research Laboratory, Ahmedabad and gave an oral presentation titled *Propagating MHD Waves in the Solar Atmosphere*; "38th COSPAR Scientific Assembly", 18th – 25th July, 2010, Bremen, Germany titled on *Accelerating disturbances in polar coronal holes* and *A study of quiet Sun oscillations using the Hinode*, SoHO and TRACE spacecrafts' in the "38th COSPAR Scientific Assembly", 18th – 25th July, 2010, Bremen, Germany.

Siraj Hasan participated in the following meetings: the International Committee of the Royal Astronomical Society, London, 6-7 May 2010; the TMT Board Meeting, June, 2010; the 3rd IIA-PennState Astrostatistics School, Vainu Bappu Observatory, IIA, Kavalur, July, 2010, which he inaugurated; *Future Out-of-ecliptic and in situ observations of the Sun*, 30 November, 2010, at the International Space Studies Institute, Bern, Switzerland, where he gave a talk on *Variable Emission Line Coronagraph on Aditya*; the Space Climate Symposium, January 17, 22, 2011, Goa, where he gave a talk on *Solar and Space Science in India*; the Humboldt Kolleg on SELF-ORGANIZED CRITICALITY: DYNAMICS OF COMPLEX SYSTEMS, February 2-5, 2011, IIA, Bangalore, where he gave a talk on *Dynamical processes in the atmosphere of the Sun*; the First Asia Pacific Solar Physics Meeting, March 21-24, 2011, IIA, Bangalore, where he gave two talks, on *National Large Solar Telescope of India*, and on *Beginning of Solar Research in India*.

K. M. Hiremath participated in the following meetings: (i) 7th Annual Meeting of Asia Oceania Geosciences Society (AOGS) organized at International Convention Centre, Hyderabad, hosted by Indian Geophysical Union during 5th - 9th July, 2010 and gave an invited talk titled *Solar and Astronomical Forcing on the Earth's Climate*; (ii) He also participated and gave an invited talk titled *Magnetic Field Structure of Mercury* at the International workshop on "Advances in Planetary Atmosphere and Exploration", from 12th -13th July, 2010 organized by Physical Research Laboratory (PRL), Ahmedabad; *K. M. Hiremath* participated in the "4th Space Climate meeting", Goa, 16th - 21th January, 2011 and presented the following posters: (i) Manjunath Hegde, K. M. Hiremath and J. B. Gurman*, *Rotation Rates of the Coronal Holes and their Probable Origin*; Manjunath Hegde, K. M. Hiremath, J. B. Gurman* and V. H. Doddamani* *Dynamical and Thermal properties of the Coronal Holes*. Hiremath also participated also presented posters at the 1st Asia-Pacific Meeting, 21 - 24 March, at IIA, Bengaluru, (i) *Dynamic and Magnetic Evolution of Sunspots from the Hinode data*, (ii) *Tilt Angle of the Bipolar Sunspots During Their Initial Appearance*, (iii) *Coronal Hole Oscillations Inferred from SDO/AIA Data*.

J. Javaraiah participated and presented a poster papers in the following meetings: *Long-term variations in the evolutions of sunspot groups*, in the symposium "Space Climate 4", held during January 16 – 21, 2011 in Goa, India; *Does the Sun's Surface Equatorial Rotation Rate Vary ?*, at the "3rd Indo – China Workshop on Solar Physics and 1st Asia Pacific Solar Physics Meeting", held at IIA during 21st – 24th March, 2011.

R. Kariyappa participated in the *International Conference on Space Climate Meeting* in Goa, 16-21 January, 2011 and presented a paper on *Irradiance Variability*; presented three postersi: *Interaction of Acoustic Waves and Intensity Oscillations with Smallscale Magnetic Features* by L. P. Chitta, R. Jain* & R. Kariyappa et al.; *First Results and Solar Irradiance Variability from PROBA2/LYRA* by R. Kariyappa et al.; *Coronal Rotation from XBPs Observed with Hinode/XRT* by R. Kariyappa, A. Agrawal* & L. P. Chitta, at the *3rd Indo - China Workshop on Solar Physics and 1st Asia Pacific Solar Physics Meeting*, IIA, 21–24 March, 2011.

Krishna Prasad participated in the following meetings: *First Asia-Pacific Solar Physics meeting*, March 21st – 24th, 2011, Indian Institute of Astrophysics, Bangalore; *Astronomical Society of India meeting*, 23–25 February 2011, Raipur, India; *Space Climate Symposium 4*, 16–21 January, 2011, Goa, India; *13th Young Astronomer's Meeting*, 3–5 September, 2010, Physical Research Laboratory, Ahmedabad India; *38th COSPAR Scientific Assembly*, 18–25 July, 2010, Bremen, Germany; *7th Annual Meeting of AOGS*, 5–9 July, 2010, Hyderabad, India.

S. P. Rajaguru attended the AOGS 2010 Meeting held at Hyderabad, India during 5th – 10th July, 2011; the IAU Symposium 273 "Physics of the Sun and Starspots", held at Ventura, CA USA during 22nd – 26th August, 2010; "3rd India-China and 1st Asia-Pacific Meeting on Solar Physics", held at IIA, Bangalore during 21 – 26 March, 2010.

S. Ramya attended the meeting on "A Universe of Dwarf Galaxies: Observations, Theories and Simulations", 14th - 18th June, 2010 at Lyon, France and presented a poster on *Star Formation and Star Formation Histories in Blue Compact Dwarf Galaxies.*

M. Sampoorna participated in the Chandrasekhar Centenary Conference, held during 7th – 11th December, 2010, at Indian Institute of Astrophysics, Bangalore, India.

H. N. Smitha attended the Chandrasekhar Centenary Conference, held during 7th - 11th December, 2010, at Indian Institute of Astrophysics, Bangalore.

S. K. Saha attended the following meetings: Chandrasekhar Centenary Conference during 7th - 11th December, 2010, held at IIA, Bangalore; 98th Session of Indian Science Congress, held at Chennai, 1st – 7th January, 2011; Chaired a session at the International Conference on "Contemporary Trends in Optics and Opto-Electronics", during 17th – 19th January, 2011, at Trivandrum; Symposium on "Advanced Measurement Techniques and Instrumentation (SAMTI)", held at Mumbai, during 2nd – 4th February, 2011.

V. Selvi attended the CPRI golden jubilee meeting on "Power systems grounding practices" from 26th – 27th October 2010 at CPRI, Bangalore.

P. Shastri participated in the 21st annual international meeting of the Third World Academy of Sciences, 19–22 October, 2010 in Hyderabad (invited talk); the 3rd IIA-PennState Astrostatics School (organiser and speaker); the NIAS-DST Seminar on *Gender Issues in Indian Science: Transcending Barriers to Performance*, 22–26 November, 2010, NIAS, Bangalore (invited lecture); the 11th international conference on Public Communication of Science & Technology, 6–10 December (invited talk), New Delhi; and in the XIIIth All-India Peoples Science Congress, Thrissur (invited talk).

A. Subramaniam attended the following meetings: (1) "Inauguration of 1.3m telescope at Devasthal and the science meeting", held in Nainital - 12th – 13th December 2010; (2) "ASI meeting" held in Raipur, 23th – 25th February, 2011; (3) "TMT-India Science meeting" held in Delhi University, 13th March 2011; (4) "TMT - science and instrumentation meeting" held in Victora, Canada - 28th – 30th March, 2011.

A. Surya participated in the "Optical Society of India Symposium XXXV: International Conference on Contemporary Trends in Optics and Opto Electronics".

Veeresh Singh participated in the following conferences: (1) "Accretion Processes around Compact Objects", 14th - 16th July, 2010, held at IISc, Bangalore, India; (2) International conference on "Accretion and Outflow in Black Hole Systems", 11th -15th October 2010, Kathmandu, Nepal, presented a poster titled *Measuring the Level of Nuclear Activity in Seyfert Galaxies and the Unification Scheme*; (3) "Wide-band X-ray Astronomy: Frontiers in Timing and Spectroscopy", 13th - 16th January, 2011, IUCAA, Pune, India, presented a poster titled *Suzaku Broad-band X-ray Spectroscopy of the Compton-Thick Seyfert Galaxy NGC 5135*; and in the "Diffuse Rela-

tivistic Plasmas Conference", 1st - 4th March, 2011, RRI, Bangalore, India.

A. Vyas participated in SPIE symposium: "Astronomical Telescopes and Instrumentation," held during 27th June – 2nd July, 2010, at San Diego, USA.

Institutional Collaborations

IIA is collaborating with the Tata Institute of Fundamental Research (TIFR), Bhabha Atmomic Research Centre (BARC) and Saha Institute of SINP Nuclear Physics (SINP) on HAGAR experiment.

Individual Collaborations

L. S. Anusha is collaborating with H. Frisch, Observatoire de la Cote d'Azur, France, on *Radiative transfer in inhomogeneous media*; J.O. Stenflo, ETH Zentrum, Zurich, Switzerland, on *Analysis and modeling of the observations of forward scattering polarization*; M. Bianda and R. Ramelli, IRSOL, Locarno, Switzerland, on *Observations of the scattering polarization with ZIMPOL III*; Frederic Paletou, University of Toulouse, France, on *Advanced Numerical Methods in Radiative Transfer.*

S. P. Bagare is collaborating on *Molecular Spectra of Sunspot Umbrae and Late Type Stars* with N. Rajamanickam, Physics Research Centre, VHNSN College, Virudhunagar.

B. C. Bhatt is involved in the following projects *GPS Geodesy* in collaboration with IIA-CMMACS; in the National Network of GPS stations in India which is a project of the Department of Earth Sciences, Govt. of India; in the project on *Atmospheric Chemistry* in collaboration with LSCE/CMMACS. He is also a co-PI for the IIA-CMMACS (N. K. Indira)-PU (Vikram Reddy), Pondicherry joint proposal funded by DST, Govt. of India for traces of Green house gases of atmosphere over Pondicherry sea shore; *Climatic Chemistry* He is a co-PI for the IIA-CMMACS (N. K. Indira)-NIOT (R. Kirubagaran)-LSCE (Michel Ramonet) joint proposal funded by CSIR, New Delhi for research on climatic chemistry over a large atmospheric grid of sea-shore near Andaman.

V. K. Gaur, T. P. Prabhu, S. P. Bagare, B. C. Bhatt, N. Shantikumar from (IIA) are involved in the project *Aerosol Characterization and Assessment of the Radiative impacts from the High-altitude trans-Himalayan site in Hanle*, Ladakh, under the ARFI project of ISRO-GBP. The others involved are K. Krishnamoorthy, Director, Space Physics Laboratory, ISRO, Trivandrum, S. Suresh Babu, Mukunda M. Gogoi, Sreekanth V., D. P. Vajja, and P. P. Pramod, Space Physics Laboratory, ISRO, Trivandrum.

S. Giridhar is collaborating with Armando A Ferro, Institute of Astronomy, Univ. Nacional Autonoma de Mexico, Mexico during 6th July, 2010 - 6th January, 2011 under the DST/CONACyt project titled *Variability in the Atmospheres of the Sun and Stars.* Work on collaborative projects on *High Galactic Latitude Post-AGB Candidates* as well on the project on CCD Photometry of Variable Stars in Globular Cluster NGC 6981 are also being undertaken.

K. M. Hiremath collaborated on the *Dynamic and Thermal Properties of the Solar Coronal Holes* with J. B. Gurman*, NASA Goddard Space Flight Center, Greenbelt, MD, USA.

R. T. Gangadhara collaborated on *Pulsars* with Y. Gupta (NCRA, Pune) and J. L. Han (NAO, Beijing, China).

R. Kariyappa & S.S. Hasan are collaborating with A. Hanslmeier from the Institut of Astronomy, Karl Franzens University, Graz, Austria, on *Photospheric triggered waves and the Heating of the Chromosphere.*

J. Murthy is collaborating with R. C. Henry from (JHU)Department of Physics and Astronomy, The Johns Hopkins University, Baltimore, USA and N. V. Sujatha (kerala) on *Diffuse UV Background*; with U. J. Sofia (Department of Physics, American University, USA), V. Parvathi (Physics Department, Department of Physics, University of Calicut, Kerala), B. R. S. Babu (Department of Physics, University of Calicut, Kerala) on *Carbon in the ISM.*

K. N. Nagendra is collaborating with H. Frisch, Observatoire de la Cote d'Azur, France, on *Radiative transfer with angle-dependent partial frequency redistribution*; J. O. Stenflo, ETH Zentrum, Zurich, Switzerland, on *The theory and application of partial frequency redistribution for a two-term atom*; M. Bianda and R. Ramelli, IRSOL, Locarno, Switzerland, *Observations of the forward Hanle scattering polarization with ZIMPOL-III*; R. Holzreuter, MPI fur Sonnensystemforschung, Germany, on *Modeling the forward Hanle scattering signatures in* Ca I *4227*

line; F. Paletou, University of Toulouse, France, on *Advanced numerical methods in Radiative Transfer.*

K. P. Raju is collaborating with T. Chandrasekhar*, N. M. Ashok* from Physical Research Laboratory, Ahmedabad on *Analysis of the coronal green line profiles"* and with B. J. I. Bromage University of Central Lancashire, UK.

M. Sampoorna is collaborating with H. Frisch, Observatoire de la Cote d'Azur, France, on *Radiative transfer with angle-dependent partial frequency redistribution*; J.O. Stenflo, ETH Zentrum, Zurich, Switzerland, on *The theory and application of partial frequency redistribution for a two-term atom*; M. Bianda and R. Ramelli, IRSOL, Locarno, Switzerland, on *Observations of the forward Hanle scattering polarization with ZIMPOL-III*; R. Holzreuter, MPI fur Sonnensystemforschung, Germany, on *Modeling the forward Hanle scattering signatures in Ca* I *4227 line*; J. Trujillo Bueno, IAC, Tenerife, Spain, and E. Landi Degl'Innocenti, University of Firenze, Italy, on *The Sensitivity of the linear polarization profiles to Atmospheric parameters.*

P. Shastri is collaborating with A. Alonso-Herrero from the Centro de Astrobiologia, INTA-CSIC, Madrid, Spain, on active galactic nuclei in the infra-red.

T. Sivarani is collaborating with T. C. Beers, Michigan State university, on the topic *Metal Poor Stars and Near Field Cosmology*; J. Ge, of University of Florida, on *Exoplanet Research*; P. Bonifacio, of Observatory Meudon, on *Metal Poor Stars in the Galaxy.*

6.3 Externally funded projects

S. Giridhar is P.I. of Indo-Mexico project on *Variability in the Atmospheres of the Sun and Stars* under India-Mexico ST programme of cooperation supported by Dept of Science and Technology. Giridhar is also PI of the project on *Design and Fabrication of High Resolution Spectrometer for 2m HCT at Hanle.* The project is supported by IRHPA scheme of DST.

A. Goswami is funded by DST, India for the project on *Determination and Mmodelling of Chemical Compositions of Metal-Poor Stars and Observational Constraints for Galacticn Chemical Evolution.*

Siraj Hasan was awarded a grant by the Alexander von Humboldt Foundation to hold a Kolleg (Conference) on *Self-organized criticality: Dynamics of complex systems*, during 2-5 February, 2011 at IIA, Bangalore; He is also Co-investigator of an Indo-Austrian International Programme with the Institute of Astronomy, Graz, Austria funded by DST for research on *Photospheric triggered waves and the Heating of the Chromosphere.*

K. M. Hiremath is the P.I for a project funded by ISRO for three years July 2010 - July 2011. The project is on *Possible Linkages between the Indian Summer Monsoon Rainfall and Solar Variability and, Genesis of Solar Cycle and Activity Phenomena.*

R. Kariyappa is the PI for an externally funded project on *Photospheric Triggered Waves and the Heating of the Chromosphere* funded by DST under Indo-Austria Exchange Programme. His collaborators are S. Hasan, G. Vigeesh, L. P. Chitta and A. Hansleier from the University of Graz.

K. N. Nagendra is the Indian PI for an Indo-Swiss project titled *Analysis and modeling of the observations of forward scattering polarization in the Ca* I *4227Å line* and M. Bianda, IRSOL, Locarno, Switzerland is the Swiss co-PI. The project is funded by DST and EPFL. The collaborators are L. S. Anusha, M. Sampoorna, H. N. Smitha, J. O. Stenflo*, R. Holzreuter*, H. Frisch*, and R. Ramelli*.

6.4 Involvement with the Scientific Community

G. C. Anupama served as (1) 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; (2) member of the Subject Expert Committee on Physical and Mathematical Sciences for technical evaluation of proposals received under Women Scientist Scheme – (WOS-A); (3) Chair, Time Allocation Committee, IUCAA Ghirawali Observatory, IUCAA, Pune (2009-2012); (4) member and Co-Chair of TMT Science Advisory Council (representing TMT-India).

S. P. Bagare served as External examiner and/or Member of Board of Exams for M.Sc. / Doctoral committees for Physics and Astrophysics at the University of Mysore, Bangalore University, and Tumkur

University, during 2010-2011.

H. C. Bhatt served as a member of the Programme Adivisory Committee on *Plasma, High Energy, Nuclear Physics, Astronomy & Astrophysics and Nonlinear Dynamics* of the DST.

S. Chatterjee served on Vigyan Prasar's expert review committee on science film script writing.

S. Giridhar is a member of Editorial Board of J. Astrophys. Astronomy, and of the IAU commission 45 on Spectral Classification.

Siraj Hasan is a member of the Organizing Committee of IAU Commission 10; member of the editorial board of *Solar Physics* and *Journal of Astrophysics and Astronomy*; member of the selection committee for the Dr. D. C. Pavate Fellowships to Cambridge University, UK; member of the International Committee of the Royal Astronomical Society, UK; the Chair of the Executive Council, Visheshwara Technological Museum, Bangalore; Member of the Governing Councils of ARIES, Nainital, Bose Institute, Kolkata, Institute of Plasma Research, Gandhinagar, IUCAA, Pune and the National Council of Science Museums, India; member of the 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; President of the Oxford and Cambridge Society of Bangalore and the Alexander von Humboldt Association of Bangalore.

K. M. Hiremath was invited by the Bengaluru University, in March 2010, to set a question paper in astrophysics (special paper) for the M Sc. Physics students.

J. Javaraiah is the lead Guest Editor for the upcoming special issue on *The Solar Cycle*, in the journal Advances in Astronomy.

A. Mangalam is serving on the editorial board of BASI since July 2010. He is also serving as the IIA representative and co-ordinator for JEST 2011; member of the Programme Coordination Commitee for the Joint Astronomy Programme.

J. Murthy is a member of the following committees: Ph.D. Committee at Bangalore University; Physics Examination Board at Bangalore University; Ph.D. Committee at Christ University; Research Advisory Board at SNBNCBS; Faculty appointment at BMS; President IAU Commission 21; Member, Organizing Committee IAU Divisions IX and XI; Promotion Committee, ISRO.

A. K. Pati continued as Board member of the 1.3m Telescope Project of ARIES and participated at the inauguration function for the telescope at Devasthal in December 2010.

T. P. Prabhu is a Member of: Project Management Board, 3.6 m Devasthal Optical Telescope, ARIES, Nainital; GMRT Time Allocation Committee, NCRA, Pune; TMT Cost Review Committee,TMT Project, Pasadena, California, USA.

Raghavendra Prasad was the Chair of the Project Review Committee for DST funded "Center for Development of fabrication facilities for optoelectronic devices based on molecular, polymeric and composite materials" at IIT-Gauhati; member of DST – Project Advisory Committee on "Molecular Electronics, Conducting Polymer Electronics, Non-invasive and other Bio-sensors"; and a Member of Board of Examiners of Sri Sathya Sai Institute of Higher Learning, Prasanthinilayam.

S. K. Saha is a Member of the Editorial Board of Asian Journal of Physics and Bhavishya – Journal of Engineering Research.

P. Shastri is a member, Organising Committee, Division X (Commission 40), of the International Astronomical Union; member of the GMRT Time Allocation Committee, TIFR; and member, Board of Studies of the Physics Department, St.Agnes College, Mangalore.

T. Sivarani is a Member of the science group: Next generation CFHT (Canada, France, Hawaii Telescope).

K. Sundar Raman is an Adjunct Faculty, and a Member of the Board of Studies in Physics in Mother Teresa Womens University, Kodaikanal.

6.5 Visits by IIA Scientists

S. P. Bagare visited the Department of Physics and Astronomy, California State University, Northridge, USA, 27th August – 5th September, 2010.

S. Chatterjee visited the Department of Physics, Shiraz University, Shiraz, Iran, during 8–9 May, 2010.

G. R. Gupta visited Max Planck Institute of Solar System Research, Lindau, Germany during 18th – 27 February, 2011.

Siraj Hasan visited the Paris Observatory, Meudon, France during 4–5 May 2010; Department of Applied Mathematics, University of Sheffield, UK during 14-17 June 2010; California Institute of Technology during 19-22 June 2010; ESO, Santiago & ALMA, Chile during 5-7 July, 2010; the International Space Studies Institute, Berne, Switzerland during 30 November-1 December, 2010; and the Department of Applied Physics, Benaras Hindu University, Varanasi, during 14-15 December, 2010.

R. Kariyappa visited Royal Observatory (ROB) of Belgium under the PROBA2 Guest Investigator Programme to work on LYRA Irradiance observations with Marie Dominique (ROB) from 18th September - 4th November 2010.

S. Krishna Prasad visited the Royal Observatory of Belgium, Brussels, Belgium during September 6th – 25th, 2010.

J. Murthy visited Weizmann Institute, Rehovot, Israel (5th – 11th June, 2010); Caltech, Pasadena, USA (17th – 22nd October, 2010); Weizmann Institute, Rehovot, Israel (13th – 17th March, 2011) The Johns Hopkins University, Baltimore, USA (16th May – 21st June, 2011)

S. P. Rajaguru visited the Solar Observatories Group, Stanford University, Stanford CA, USA during 28th August – 5the September, 2010 for collaborative work.

S. Ramya visited Kapteyn Astronomical Institute during 23rd - 24th June, 2010 and gave a talk on *Star Formation in Blue Compact Dwarf Galaxies* on 23rd June, 2010. She visited NCRA, Pune and presented a talk on *Star Formation and Star Formation Histories in Blue Compact Dwarf Galaxies* on 16th August, 2010.

M. Safonova visited the Sternberg Astronomical Institute, Moscow State University, Moscow, Russia, in June, 2010.

P. Shastri visited the Kavli Institute for Particle Astrophysics, Stanford University, during 15-30 September, 2010.

P. R. Vishwanath visited Karnatak Univerity, Dharwar on 5th and 6th August 2011, and gave a lecture on *Basic Astronomy and Astrophysics*. He also visited TIFR, Bombay and gave a lecture on *Progress in Gamma Ray Astronomy* on 29th November, 2011. He also visited Mt Abu and gave spoke on the *TACTIC experiment* on 29th and 30th of March 2011.

6.6 Awards and Recognition

Siraj Hasan is an Associate of the Harvard College Obsevatory, Cambridge, USA, since 1991, and Distinguished Adjunct Professor, Centre for Astroparticle Physics, Kolkata.

Avijeet Prasad

Avijeet Prasad, 2nd year M.Sc student in the first batch of the IIA-IGNOU Integrated M.Sc-Ph.D. Programme stood third in the national level CSIR-NET exam held during June 2010.

Sandra Rajiva

S. Rajiva was felicitated at the 29th Meeting of the Astronomical Society of India held at the Pt Ravishankar Shukla University, Raipur during February 23 - 25, 2011. This was in recognition of her fruitful association with the Bulletin of the ASI for nearly 25 years. She was honoured with a memento, a citation and a shawl.

K. Soumya receiving the award at the convocation.

K. Sowmya a Junior Research Fellow at IIA, obtained her Masters degree in Physics in 2010, securing the first rank from Bangalore University. She was awarded six gold medals during the forty sixth annual convocation of the Bangalore University held on 15th February, 2011.

6.7 Welfare of SC/ST Staff

A senior officer of the institute has been functioning as the liaison officer to support the welfare of the SC/ST staff members. Special consideration as per norms during recruitment and regular assessment has been provided to these categories of employees. As of the end of the year, members belonging to the SC and ST categories constitute 16% and 10.3% respectively of the total staff strength. In addition, reservations continue to be extended to OBCs and physically disabled persons. Proactive efforts are continuously made towards their welfare. Facilities and mechanisms have been provided for special administrative as well as technical training of staff from the historically disadvantaged categories.

6.8 Official Language Implementation

Several multifaceted activities were organised in the institute to enhance the Hindi skills of employees and propel the implementation of the official language. Reports of these activities were regularly sent to the Department of Science & Technology, New Delhi.

Official Language Implementation Committee: Official Language Implementation Committee meetings were conducted on 28th June, 2010, 20th September, 2010, 30th December, 2010 and 16th March, 2011 respectively in the Institute.

Hindi Workshop: Four Hindi workshops were conducted for the employees in Administration. on 9th June, 23rd September, 21st December, 2010 and 10th March, 2011 respectively.

Incentive Scheme: Under this scheme, two "One word scheme" competitions were conducted for employees working in Administration on 30th November, 2010 and 27th April, 2011 respectively. Winners were awarded cash prizes.

Hindi Day / Fortnight Celebration: In the Institute, Hindi Fortnight was celebrated during 1– 14 September, 2010. Five competitions were conducted in the Institute viz. a Hindi Debate on 1st Septem-

Hindi workshop, 27th April, 2011. Standing, Left to Right: N.Satyabama, Uma Mailavelu, Vilva Kumar, K.Rangaswamy, V.Natarajan, B. Pranesh Rao, Dhananjaya, Y. Yerrappa, K.Shankaranarayanan, Malini Rajan. Sitting, Left to Right: M. Purushotham, P. Kumaresan and S. Rajnatesan.

ber, 2010, a Hindi Song Competition on 3rd September 2010, Hindi "Antyakshari" on 6th September, 2010, Hindi Essay Writing on 7th September 2010, and a Hindi Translation competition on 8th September, 2010.

On *Hindi Diwas*, which was celebrated on 14th September 2010, P. Kumaresan, the Institute's Administrative Officer addressed the audience and said that it was the moral responsibility of all staff members to accomplish official work in simple hindi. R. C. Kapoor read the Home Minister's message for Hindi Day and Narasimha Raju, gave the vote of thanks.

Hindi Day/Fortnight in field stations: On occasion of Hindi Fortnight celebrations, two hindi competitions were conducted viz. Hindi Song and Hindi Anthakshri on 16 September, 2010. Winners were distributed with cash awards.

Purchase of books for Hindi Library: As per guidelines laid by the Official Language Department, Home Ministry, Govt. of India, new hindi books have been purchased and added to the existing collection.

(S. Rajnatesan, Hindi Cell)

Competition winners, Hindi Fortnight Celebrations, September, 2010. Left to Right: M. Purushotham, Meena, N. Satyabama, Malini Rajan, Dr. P. Kumaresan, Prof. R. C. Kapoor, N. K. Pramila, L. Josephine, B. Pranesh Rao.

Chapter 7

People

7.1 Staff List 2010 – 2011

Director: S. S. Hasan

7.1.1 Academic & Scientific Staff

Senior Professor: B. P. Das, T. P. Prabhu, C. Sivaram

Professor: S. P. Bagare, H. C. Bhatt, S. Giridhar, J. Murthy, K. N. Nagendra, A. K. Pati, A. V. Raveendran, S. K. Saha

Associate Professor: G. C. Anupama, S. Annapurni, D. Banerjee, S. Chatterjee, R. K. Chaudhuri, V. Chitnis, R. T. Gangadhara, K. M. Hiremath, R. Kariyappa, S. G. V. Mallik, A. Mangalam, M. V. Mekkaden, B. R. Prasad, K. E. Rangarajan, K. P. Raju, K. B. Ramesh, R. Ramesh, B. Eswar Reddy, D. K. Sahu, A. Satyanarayanan, S. K. Sengupta, P. Shastri

Reader: P. Chingangbam, M. Das, J. Javaraiah, C. Muthumariappan, G. Pandey, S. P. Rajaguru, T. Sivarani, C. S. Stalin, F. Sutaria

Scientist D: B. C. Bhatt, A. Goswami, U. S. Kamath, S. Muneer, P. S. Parihar, M. S. Rao, K. Sundara Raman, B. A. Varghese

Scientist C: R. K. Banyal, E. E. Chellasamy, B. S. Nagabhushana, B. Ravindra, N. S. Singh

Scientific Officer SD: R. Mohan, L. Yeshwanth

Scientist B: N. A. Ahmed, P. Bama, N. Dorjey, K. Prabhu, M. Priyal, R. B. Singh, G. S. Suryanarayana

Fellow: C. Kathiravan

Research Associate: M. Appakutty, G. Selvakumar

Adjunct Professor: A. R. Choudhuri

Honorary Professor: V. K. Gaur, R. Srinivasan, K. R. Subramanian, S. N. Tandon, P. R. Vishwanath

Visiting Professor: J. Singh

Chandrasekhar Post-Doctoral Fellow: M. Sampoorna

Post Doctoral/Visiting Fellow: S. V. Anathpindika, M. Safonova, G. Vigeesh

Sr. Research Fellow: L. S. Anusha, K. Chandrashekar, R. Chaudhari, A. Dhar, G. R. Gupta, B. P. Hema, S. Indu, D. Kumar, G. U. Kumar, A. C. Pradhan, S. K. Prasad, M. Prasanth, A. Shukla, P. Ramya, S. Ramya., S. Rao, S. Rathna Kumar, M. B. Roopashree, G. Sindhuja, V. Singh, S. Subramaniam, A. Vyas, B. K. Yerra Reddy

Jr. Research Fellow: S. Arun, R. Balasudhakar, A. Chanumolu, L. P. Chitta, S. Choudhury, Drisya, M. Das, S. K. Dhara, S. S. Kartha, A. Prasad, K. S. Raja, C. R. Sangeetha, H. N. Smitha, K. Sowmya, N. V. Suresh, H. D. Supriya

IIA-IGNOU Integrated M.Sc, Ph.D.: S. Kumar, S. Nanda, M. Sastry, M. Singh, S. Srivastav, S. P. Vaidehi

IIA-CU M. Tech-Ph. D: S. Behra, K. Hariharan, A. Mohanty, S. Pal, K. Pullapally, J. Paul, N. Reddy, T. K. Sharma, A. G. Sreejith, A. Surendran

7.1.2 Technical Staff

Engineer G: A. K. Saxena

Sr. Principal Scientific Officer: A. V. Ananth

Engineer F: V. C. Chinnappan, M. S. Sundararajan

Engineer E: G. Srinivasulu

Engineer D: V. Arumugam, S. S. Chandramouli, P. M. M. Kemkar, P. K. Mahesh, S. Nagabushana, M. V. Ramaswamy, 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, K. Dhananjay, T. Dorjai, S. Gorka, S. Kathiravan, P. U. Kamath, A. Kumar, K. C. Thulasidharan

Sr. Technical Officer: K. Jayakumar, K. Kuppuswamy, K. Rangaswamy, M. J. Rosario, A. Selvaraj, R. Selvendran

Technical Officer B: J. V. S. V. Rao, N. Sivaraj, K. S. Subramanian

Sr. Documentation Officer: S. Rajiva

Engineer B: K. Anupama, S. Jorphail, T. T. Mahay, M. F. Nawaz, A. Ramachandran, K. Ravi, V. Selvi, S. Suresh

Technical Officer: A. V. V. Kutty

Tech. Associate B: D. Babu, Narasimhappa, S. Pukalenthi, M. R. Somashekar, C. V. Sriharsha

Sr. Mech. Asst. C: A. Mani

Tech. Associate: V.Gopinath, P. Kumaravel, M. G. Mohan,Mallappa, J. Manoharan, S. Ramamoorthy, S. Venkateshwara Rao

Draughtsman E: V. K. Subramanian

Sr. Tech. Asst. B: A. P. Balakrishnan, R. I. Jabillullah, D. Kanakaraj, A. Muniyandi, T. K. Muralidas, M. Nagaraj

Asst. Librarian A: B. S. Mohan, P. Prabahar

Consultant: K. Chandar

Consultant Engineer: M. N. Karthikeyan, B. S. Nataraju, M. N. Rao, V. N. Rathnam

7.1.3 Administrative Staff

Administrative Officer: P. Kumaresan

Dy. Administrative Officer: S. Rajasekaran

Personnel Officer: A. Narasimharaju

Staff Officer: K. Thiyagarajan

Accounts Officer: M. P. Parthasarathy

Asst. Administrative Officer: Y. K. R. Iyengar

Asst. Accounts Officer: G. R. Venugopal

Stores Officer: D. Lakshmaiah

Sr. Section Officer: L. Josephine, Meena, A. P. Monnappa, P. Mohan, K. Sutherson

Section Officer: N. Murthy, K. Padmavathy, S. Rajendran, S. B. Ramesh, Ramaswamy, N. Valsalan

Section Officer (Hindi): Rajanatesan

Sr. Office Superintendent: D. Dakshinamoorthy, U. Maileveloo, G. A. Mary, N. K. Pramila, M. G. C. Nair, M. Rajan, N. Sathya Bama, A. Veronica

7.2 Visitors to IIA

Ramesh Pai
Goa University
Goa
4 – 11 April, 2010

Jean-Claude Vial
Institut d'Astrophysique Spatiale, Orsay, France
12 – 15 April, 2010

Andre Beteille
Delhi University, New Delhi
16 April, 2010

Pravabati Chingangbam
Sejong University
South Korea
17 May 2010

N. Mukunda
Indian Institute of Science, Bangalore
25 May, 2010

Uttam Singh Mahapatra
Moulana Azad College
Kolkata, West Bengal,
27 May – 12 June, 2010

Anantha Krishnan
The Department of Science & Technology
Technology Bhavan
New Mehrauli Road New Delhi 110 016
28 – 29 May, 2010

Georgeta Maris
Institute of Geodynamics, Bucharest
Romania
28th June - 4th July, 2010

Mansi Kasliwal
California Institute of Technology, USA
1 June, 2010

Ajay Ghosh
Calcutta University
87/1, College Street, Kolkata -700 073
West Bengal
1 – 3 June, 2010

S. Nayak
Birla Institute of Technology & Science
Pilani
Rajasthan 333031
2 June, 2010

C. K. Ghosh
National Centre for Innovations in Distance Education (NCIDE)
Indira Gandhi National Open University (IGNOU)
New Delhi
5 – 6 June, 2010

Kamel Patil
Jaypee Institute of Information
Technology University
Noida, Delhi
7 June – 7 August, 2010

Kiran Jain
National Solar Observatory
Tucson, USA
10 – 23 June, 2010

C. K. Ghosh
National Centre for Innovations in Distance Education (NCIDE)
Indira Gandhi National Open University (IGNOU),
New Delhi
25 – 26 June, 2010

John B. Hutchings
National Research Council, Canada
27 June – 3 July, 2010

Georgeta Haris
Institute of Geodynamics of the Romanian Academy,
Romania
28 June – 4 July, 2010

Sundar Srinivasan
Institut d'Astrophysique de Paris
France
18 June, 2010

B. N. Dwivedi
Banares Hindu University
Varanasi 221005
Uttar Pradesh
7 – 10 July, 2010

Jean-Pierre Rozelot
Observatoire de la Cte d'Azur
Universit de Nice
Dpartement LAGRANGE

Avenue N. Copernic
FR 06130 Grasse, France
7 –12 July.2010

Stuart M. Jefferies
Institute for Astronomy
University of Hawaii, Hawaii
8 – 13 July, 2010

Armando Arellano Ferro
Universidad Nacional Autonoma de Mexico
UNAM, MX Mexico DF 04510
Mexico
July 8 – December 6, 2010

Jean-Pierre Rozelot
Nice University, France
8 July, 2010

Noah Brosch
Tel Aviv University, Isreal
22 – 26 July, 2010

A. C. Gupta
ARIES
Manora Peak
Nainital 263129
28 July – 2 August, 2010

Paul J. Wiita
The College of New Jersey
E- Wing, NJ, USA
28 July – 2 August, 2010

Jayesh Bhatt
Brunel University
UK
9 August – 1 September, 2010

Govindarajan Padmanaban
Indian Institute of Science,
Bangalore
10 August, 2010

Arnab Rai Choudhuri
IISc, Bangalore
7 September, 2010

Dirk Soltau
Kiepenheuer Inst f Sonnenphysik
Germany
15 – 21 September, 2010

Victor Fedun
The University of Sheffield
UK
20 September – 6 October, 2010

T. Rengarajan
Tata Institute of Fundamental Research
Colaba, Mumbai 400 005
3 – 9 October, 2010

Dharam Vir Lal
Harvard-Smithsonian Center for Astrophysics
USA
7 October, 2010

S. P. Rao
Pondicherry University
Pondicherry
22 – 24 October, 2010

Rohan Eugene Louis
Udaipur Solar Observatory
USO
28 October, 2010

Dirk Soltau
Kiepenheuer Inst f Sonnenphysik
Schoneckstr 6, DE 79104 Freiburg Breisgau
Germany
13 – 18 November, 2010

Ram Ajor Maurya
Udaipur Solar Observatory, Physical Research Laboratory
Ahmedabad
25 November, 2010

Uttam Sinha Mahapatra
Moulana Azad College
Kolkata
27 November – 3 December, 2010

P. K. Mukherjee
Ramakrishna Mission Vivekananda University & Visva Bharati, Santiniketan, West Bengal
2 December, 2010

Frank Hill
National Solar Observatory
USA
12 – 17 December, 2010

Bhodadhitya Santra
The Kernfysisch Versneller Instituut (KVI)
KVI, Groningen, Netherlands
13 – 15 December, 2010

Poonam Chandra
Royal Military College, Canada
16 December, 2010

L. Saha
Saha Institute of Nuclear Physics,
Calcutta, 700 064
21 – 31 December, 2010

Ramarao Tata
Instituto de Astrofisica de Canarias, Spain
20 – 21 December, 2010

Masayuki Yamanaka
Hiroshima University
Hiroshima
28 December – 4 January, 2011

Nozomu Tominaga
Konan University, Japan
30 December, 2011

Indranil Chattopadhayay
ARIES
Nainital 263129
3 – 6 January, 2011

C. K. Ghosh
Indira Gandhi National Open University
New Delhi
7 – 8 January, 2011

H. Frisch
Observatoire de la Cote dAzur, Nice, France
15 December, 2010 - 13 January, 2011

Shrinivas Kulkarni
California Institute of Technology
USA
10 January, 2011

Ambrogio Fasoli
Ecole Polytechnique Federal of Lausanne
Switzerland
11 January, 2011

Arthur I. Miller
University College
London, UK
13 January, 2011

Tapan Mishra
George Town University
USA
14 – 18 January, 2011

G. Thejappa
Goddard Space Flight Center
National Aeronautics and Space Administration
USA
15 – 29 January, 2011

N. Udaya Shankar
Raman Research Institute, Bangalore
18 January, 2011

S. Turck-Chieze
IRFU, CEA
France
24 January, 2011

Donald M. Hassler
Southwest Research Institute, Colorado, USA
24 January, 2011

David Buckley
SALT, South African Astronomical Observatory
Cape town, South Africa
24 – 27 January, 2011

Shravan Hanasoge
Princeton University, Princeton, USA
28 January, 2011

Almudena Alonso-Herrero
Centro de Astrobiologia, INTA-CSIC, Madrid, Spain
30 January – 9 February, 2011

Hans Meinhardt
Max Planck Institute for Developmental Biology
Tubingen, Germany
2 February, 2011

Roddam Narasimha
Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore
3 February, 2011

Jim Burge
University of Arizona
USA
16 February, 2011

Joe Postma
University of Calgary
Canada
7 – 12 February, 2011

Wei-Tou Ni
National Tsing Hua University
Taiwan
15 February, 2011

Vijay Kapur
Indira Gandhi National Open University (IGNOU),
New Delhi
16 – 19 February, 2011

D. Sen
Centre for High Energy Physics, IISc
Bangalore
1 March, 2011
Rajesh Gopal
Bose Institute
Calcutta
5 – 11 March, 2011

John Hutchings
National Research Council
Canada
14 – 19 March, 2011

Priyam Das
Indian Institute of Science Education and Research (IISER)
Sector-III, Salt Lake City
Kolkata - 700106
27 – 29 March, 2011

S. Sridhar
Raman Research Institute, Bangalore
29 March, 2011

Phani Murali Krishna
Indian Institute of Tropical Meteorology
Pune
28 – 29 March, 2011