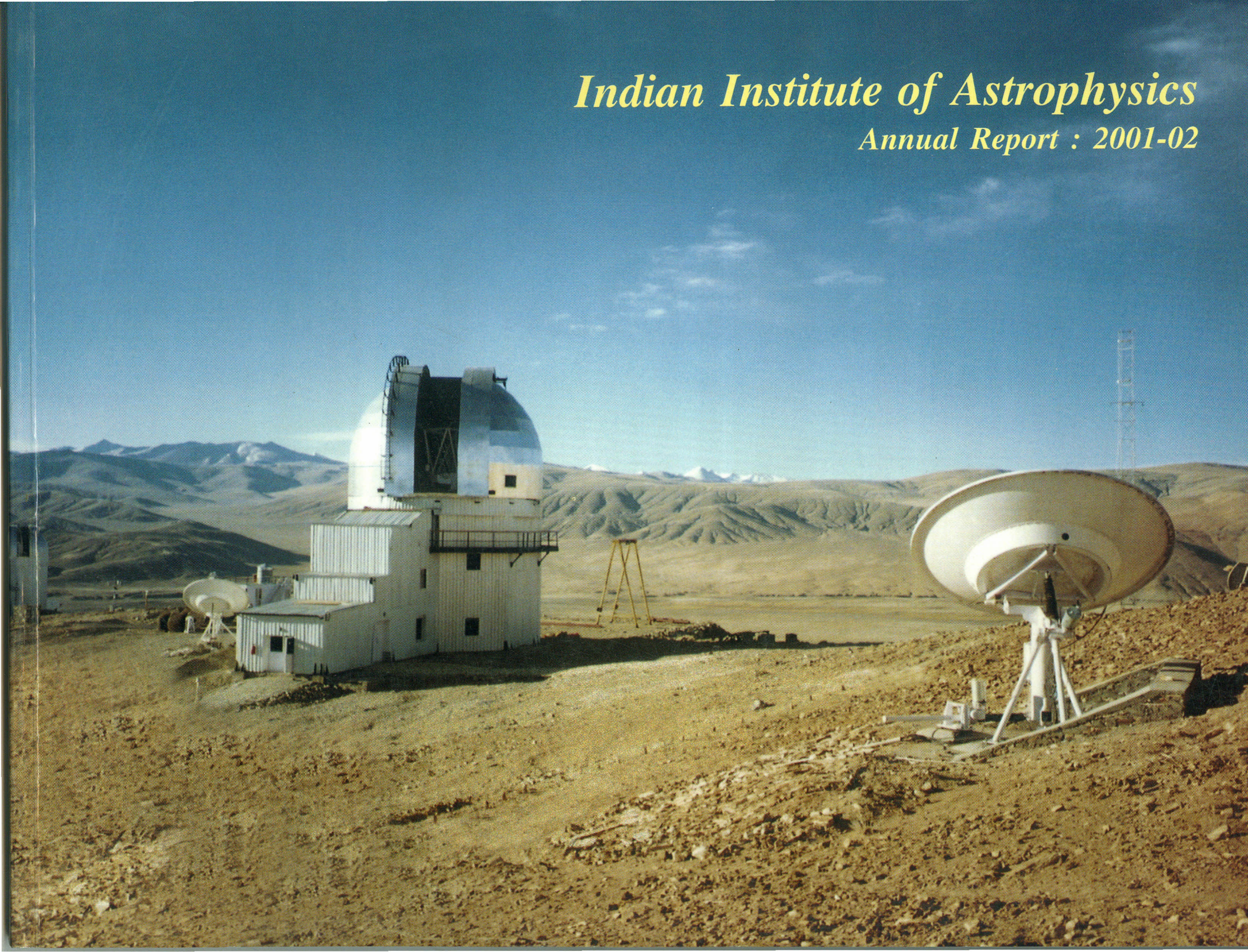
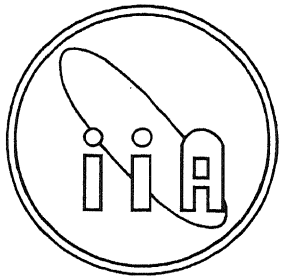
Indian Institute of Astrophysics

Annual Report : 2001-02



INDIAN INSTITUTE OF ASTROPHYSICS



ACADEMIC REPORT
2001-02

Edited by : R.C. Kapoor

Editorial assistance : Sandra Rajiva

Front cover : Indian Astronomical Observatory (IAO) atop Mt. Saraswati, Hanle - a panoramic view.

Back cover : IAO, Hanle, another view.

Printed at : Vykat Prints Pvt. Ltd., Airport Road Cross, Bangalore 560017

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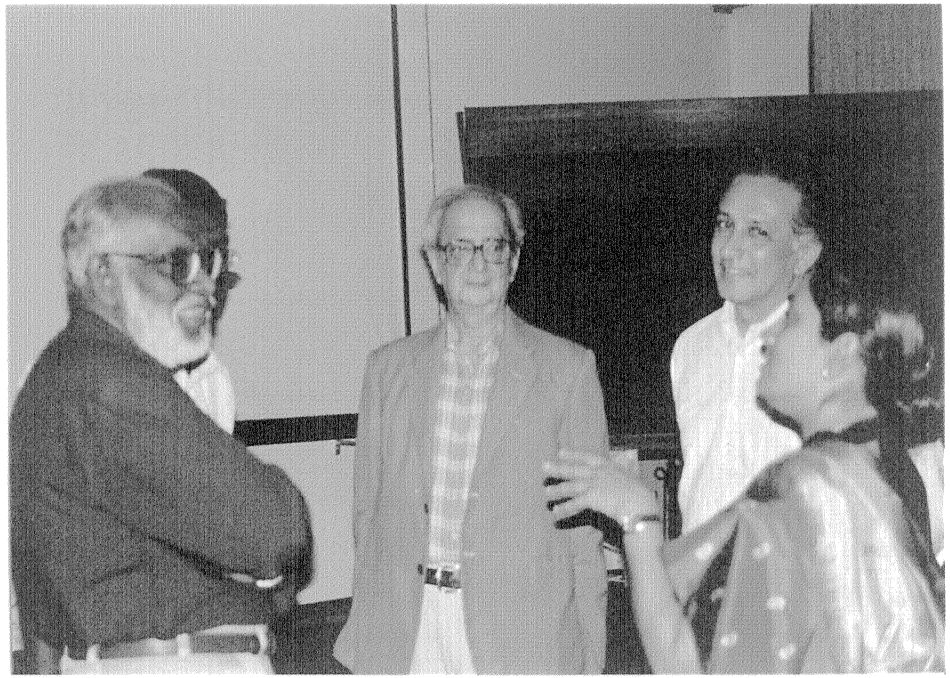

Profs. N. Kochupillai, B.V. Sreekantan, R. Cowsik in conversation, after the 16th IIA Bicentemial lecture on March 15, 2002.

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Honours & Awards :

R. Cowsik

- Padma Shri,
- INSA Jawaharlal Nehru Centenary Lecture,
- 63rd Acharya J.C.Bose Memorial Lecture of the Bose Institute, Kolkata.

Vinod Krishan

- Senoir Associateship at The Abdus Salam International Centre for Theoretical Physics, Trieste, extended upto 2007.

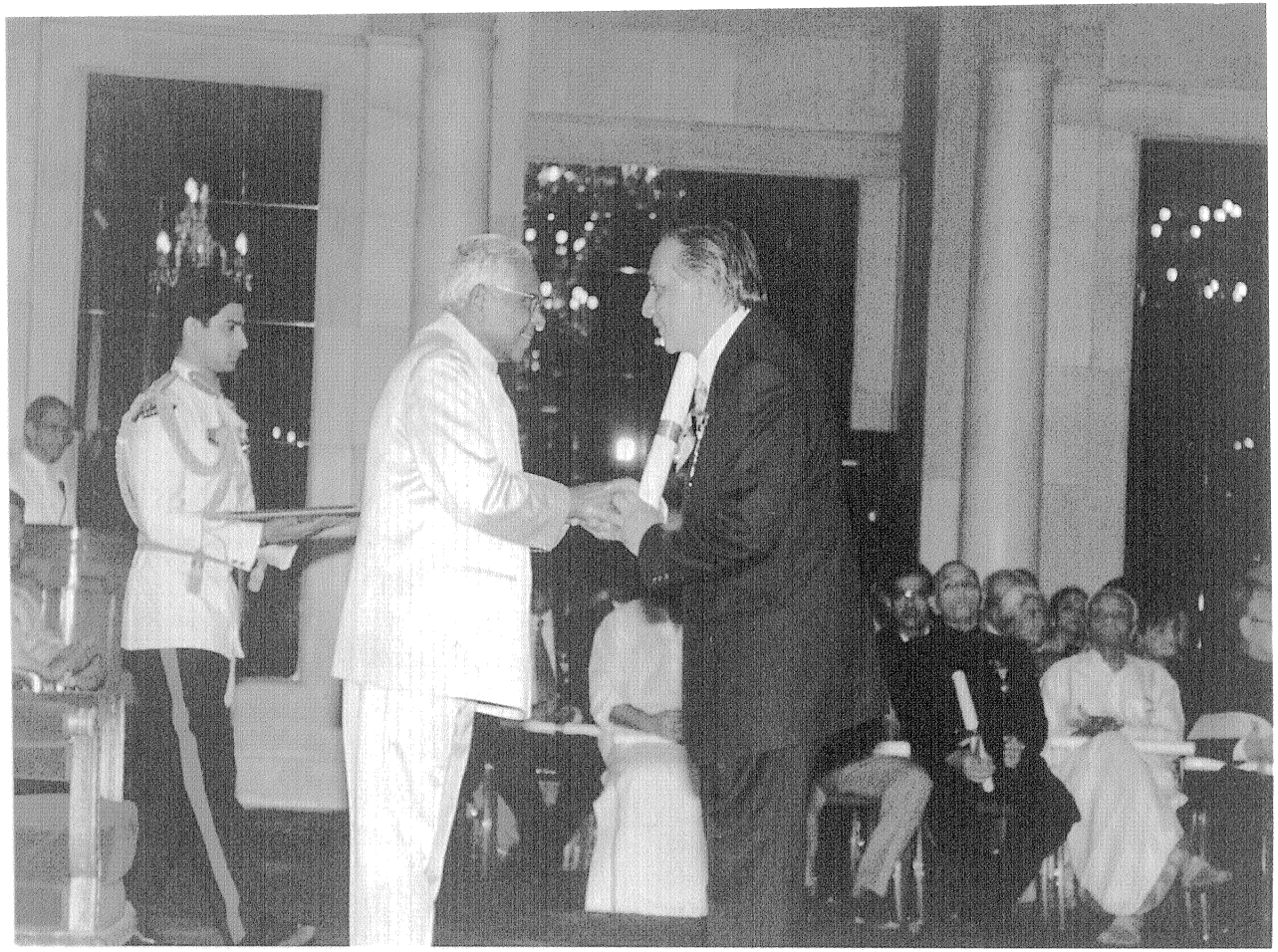
C. Sivaram

- Honorable Mention for his paper "Gravity on large and small scales : submillimetre constraints" from the Gravity Research Foundation, Massachussetts, USA.

Bicentennial Lecture :

Prof. N. Kochupillai delivered the 16th IIA Bicentennial Commemorative Public Lecture on 'Neuro-Endocrinology : Linking Body, Mind and Conciousness', on March 15, 2002.

Prof. N. Kochupillai (right) with Prof. Ramanath Cowsik.



His Excellency, Shri. K.R. Narayanan, President of India, presenting the Padma Shri award for the year 2002 to Prof. Ramanath Cowsik.

The year in review

The new millennium has dawned with great promise and excitement. The Indian Institute of Astrophysics is poised on the spring board to take off with confidence inspired by the success of the past decade and created by the great opportunities that lie ahead in the fields of astronomy, physics and related fields. I therefore feel that it is appropriate to begin the review of the activities during the year by expressing my indebtedness and that of the Institute to those whose perception, guidance and support have been responsible for the progress of the Institute and its achievements during the recent years. The Government of India through the Department of Science and Technology has provided funds generously for the various scientific projects of the Institute. As clearly brought out in the reports of the previous years this has resulted in the establishment of the Indian Astronomical Observatory, the highest in the world, of which the Nation may justifiably feel very proud indeed. All members of the Institute and I in particular are very thankful for this support and the confidence vested in us. Other departments of the government have also contributed significantly towards this achievement. I have detailed these elsewhere; yet, I would like to acknowledge here the support provided to us by the Department of Space and the Department of Telecommunications. The Governing Council of the Institute, comprising of eminent scientists, and senior officers of the Department of Science & Technology has provided constant guidance and support not only on scientific matters but also those pertaining to finance and management. These, in no small measure, have been responsible in bringing the Institute to its current vibrant state.

The Institute has established the highest observatory in the world on Mt. Saraswati in the Himalayas, where a new technology telescope is making astronomical observations in the optical and infrared bands. This telescope is operated from CREST, Hosakote near Bangalore, through a dedicated satellite communication link. This link was inaugurated on June 3, 2001 by Dr. Farooq Abdulla, Hon'ble Chief Minister of Jammu and Kashmir by having a real-time teleconferencing from the Observatory site in Hanle with Professor B.V. Sreekanten, Chairman of the Governing Council of the Institute. The formal dedication of the Observatory and the christening of the telescope as the Himalayan Chandra Telescope - in the name of the great Indian astrophysicist Professor Subaramanian Chandrasekhar, Nobel Laureate, took place on August 29, 2001. It was a grand ceremony held in the evening, with distinguished astronomers and scientists from various parts of India and across the world being present providing a high intellectual atmosphere to the proceedings. Dr. Murli Manohar Joshi, Hon'ble Minister, Human Resource Development, Science & Technology and Ocean Development, Government of India, communicated the dedication address through Professor V.S. Ramamurthy, Secreatry, Department of Science & Technology. The dedication ceremony was followed by a three day seminar reviwing the current status and the future prospects in the field of astronomy. Among the many distinguished astronomers present I would like to mention Professor Steven Beckwith, Director, Space Telescope Institute, USA who, apart from technical lectures, also delivered a public lecture with a large number of beautiful images of the astronomical objects taken with the Hubble Space Telescope.

Before highlighting the activities and achievements during the current year, I would like to briefly look into the future and consider the major projects that the Institute would like to take up in the coming decade. We may recall that the main objective of establishing the Indian Astronomical Observatory at Hanle in south-eastern Ladakh, was to prove convincingly the exquisite quality of the site to carry out astronomical observations. These efforts by the Indian Institute of Astrophysics have shown that the site in Hanle is excellent for astronomy not only in the visible band but also in the infrared and high energy gamma rays, spanning highest and the lowest bands of the electromagnetic spectrum, except those narrow bands where the absorption by the earth's atmosphere becomes very high. These efforts have also shown that operational difficulties of remoteness and high altitude can and have been overcome by technological innovation and perseverance. Thus the dreams of the Indian scientific community, so very eloquently voiced by Professor Megh Nad Saha, lie at the threshold of becoming a reality. Saha realized that it was very important for India to have a large optical telescope and his ideas are more relevant today than ever before; keeping in mind the importance of studying

astronomical objects which vary with time, the location of India in the longitude region near the middle of the eastern hemisphere is particularly important. The Indian Astronomical Observatory lies midway between the astronomical facilities on the east coast of Australia and in the Canary Islands which span a longitude band of ~ 180°; from this vantage position, India could play a crucial role in the ongoing efforts to observe astronomical objects continuously by a series of telescopes deployed around the globe. When an astronomical object sets below the western horizon in Australia it could be picked up rising above the eastern horizon in India, and then eight hours later pass the baton on to the European telescopes on the Canary Islands for further observation. A well thought out plan has already been projected by the Department of Science and Technology for setting up a Himalayan Binocular Telescope at Hanle. This of course, is a mega-project requiring the active participation of a large number of universities. Furthermore, following the internationally well-established practice for such mega-projects, it would be appropriate to share the effort and the expenses of such an enterprise with international partners. What is needed at this time for India is to make a commitment to establish such a major facility taking up the responsibility for about half the total cost of the project which works out to be a commitment of ~ Rs. 200 crores to be expended in the next seven years. With such a commitment, two or three international partners may be invited to contribute together an equal amount mostly in terms of technical design, hardware and focal plane instruments. We already know that the University of Arizona, the Steward Observatory and the Washington University are enthusiastic about the Hanle site and are expected to come forward when the project is launched by India. The launching and execution of such a mega-project would necessarily require leadership at the highest level. Such an effort by India is feasible, and worthwhile.

Another of Megh Nad Saha's suggestions has provided the motivation for the Ultra Violet Imaging Telescope proposed by the Institute as a part of the ASTROSAT, a satellite to be launched by the Indian Space Research Organization, dedicated to multiband space astronomy. Whereas the X-ray part of the pay-load is the responsibility of the Tata Institute of Fundamental Research, the UV payload will be developed by the Indian Institute of Astrophysics, with ISRO collaborating closely with both the institutions. The satellite is scheduled for launch either late in the year 2006 or in early 2007. Once these telescopes are in space and are scanning the skies we will be able to study a very wide range of astrophysical phenomena ranging from accretion onto compact objects like neutron stars and black holes of material from companion stars, to formation of stars themselves by the condensation of interstellar clouds, especially in distant galaxies. A new initiative has been taken in Hanle, following the theoretical studies that indicated that the high altitude of Hanle is of tremendous help in reducing the threshold energy for observation of gamma rays to ~ 30 GeV, using atmospheric Cerenkov radiation emitted by the cascade they generate in the upper atmosphere. A gamma ray telescope has been designed for deployment at Hanle and fabrication is in progress.

The Institute has made good progress during the year, consolidating a variety of programs taken up during the IX-Plan period, in the areas of Astronomy, Physics, Mathematics and Instrumentation. Here I would like to very briefly review this progress and refer the interested persons to the detailed reports given in the Annual and the Academic Reports:

The year 2001-02 may justly be called the year of instrumentation based on the large number of remarkable instruments developed and deployed for a variety of measurements and observations. Amongst the astronomical instrumentation I would like to mention the Large format optical imager, the Hanle Faint Object Spectrograph and Camera (later renamed as Himalayan Faint Object Spectrograph and Camera), and the 220 GHz radiometer measuring the water vapour, all deployed at Hanle, and an Echelle spectrograph located at the Vainu Bappu Observatory at Kavalur. A large plant capable of providing a reflective coating to mirrors of diameters of ~ 2 m has reached Hanle, ready for installation. The radio astronomical array operating at decametric wavelengths in Gauribidanur has been refurbished and is now capable of tracking astronomical objects, instead of acting, as it did in the past, merely as a transit instrument. The system is in place for the digitization of spectroheliographs and white light pictures of the Sun taken from the Kodaikanal Observatory, daily over the last hundred years, and work is progressing in collaboration with scientists from Japan. The suspension and the drive of the dome of the 2-m telescope at Hanle has been improved and the remote operations from CREST in Hosakote is absolutely smooth and trouble free. A large number of seismographs have been setup across India

forming a part of the national net work. Careful GPS studies across the subcontinent are monitoring the tectonic movements. A 1 m mirror has been ground and polished to replace the primary mirror of a telescope at VBO, Kavalur. A large profilometer to characterize variety of optical surfaces has been developed and another is under construction for deployment at the synchrotron facility at Indore. The communication networks, both the LAN within the Bangalore campus and the inter-campus VSAT have been refurbished with increased band width.

Turning now to specialized instruments for studies in physics or more specifically non-accelerator particle physics, a high resolution optical lever of high dynamic range has been developed by the Institute. This optical lever works in the autocollimating mode and has an angular resolution of ~ 10^{-8} rad $Hz^{-1/2}$ and a dynamic range exceeding 10^6. This autocollimator is utilized for measuring accurately the deflection angle of highly sensitive torsion balance. With this balance the Institute will confirm for the first time the existence of

Dr. Farooq Abdulla with Prof. R. Cowsik at Hanle, at the time of inauguration of the communication link between Hosakote and Hanle on June 3, 2001, in the 2m telescope house.

finite temperature effects of Casimir force, generated by the "vacuum' of quantum electrodynamics. An atomic beam apparatus has also been developed for studying the Casimir-Polder force, a closely related phenomenon. We expect exciting new results very shortly from these two instruments.

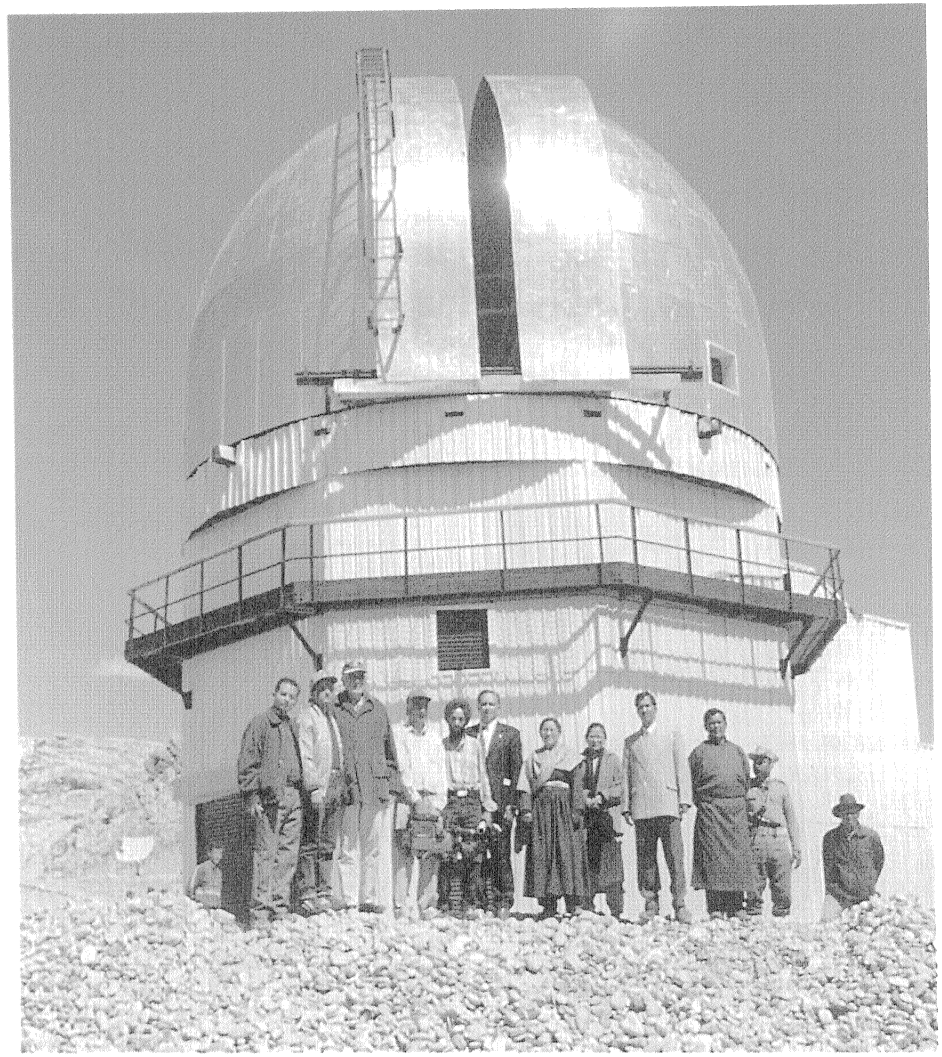
The large number of research papers and related publications indicate that the scientists and astronomers of the Institute are not only involved in the utilization of the facilities in-house, but also are making full use of the opportunities provided by other national and international facilities such as the Giant Meterwave Radio Telescope near Pune.

The programmes for guiding students during their doctoral research and engineers in advanced technology are operating with undiminished vigor. The Institute also actively participates in inter institutional programs like JEST and JAP. Collaborations with scientists both within India and from across the world have been taken up on several fronts.

We have had many distinguished visitors to the Institute and most notably Sir, Professor Arnold W. Wolfendale of Durham, UK. We have been very fortunate to have had Professor, Dr. N.Kochupillai deliver the lecture in the bicentennial series. In his highly thought provoking lecture on neuro-endocrinology he described how his assaying methods identified the incidence of cretinism and several other physical and mental disorders due to inadequate iodine intake in several parts of the country. The problems had reached epidemic proportions and he successfully negotiated the introduction of iodized salt for all dietary purposes in India thereby eradicating hypothyroidism. It was indeed a great honour for the Institute to have had a lecture by one who had contributed so much to the health of several hundred million people.

I would like to conclude this review of the activities of the year by noting that the efforts of the scientists have led to formal recognition both in the national and international forums, notably, honourable mentions by the Gravity Research Foundation, USA Senior Associateship at the The Abdus Salam International Centre for Theoretical Physics, Italy, Jawaharlal Centenary Lecture award and the Padma Shri award by the President of India.

Ramanath Cowsik
Director

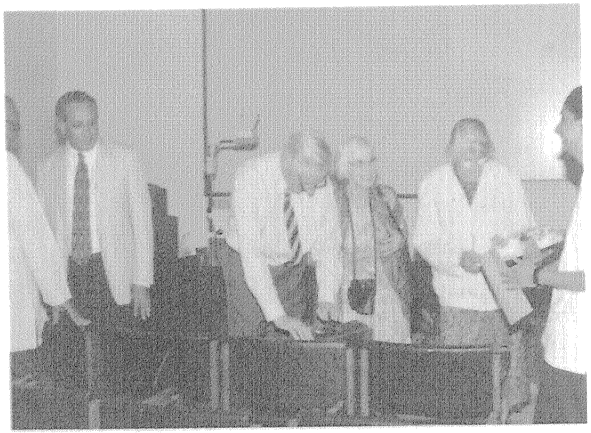


Dr. Farooq Abdulla, Hon. Chief Minister of Jammu & Kashmir, visits IAO, Hanle - June 3, 2001.

Inauguration of Satellite Communication Link at Hosakote on June 3, 2001 by Prof. B.V. Sreekantan ; also seen is Prof. N.K. Rao

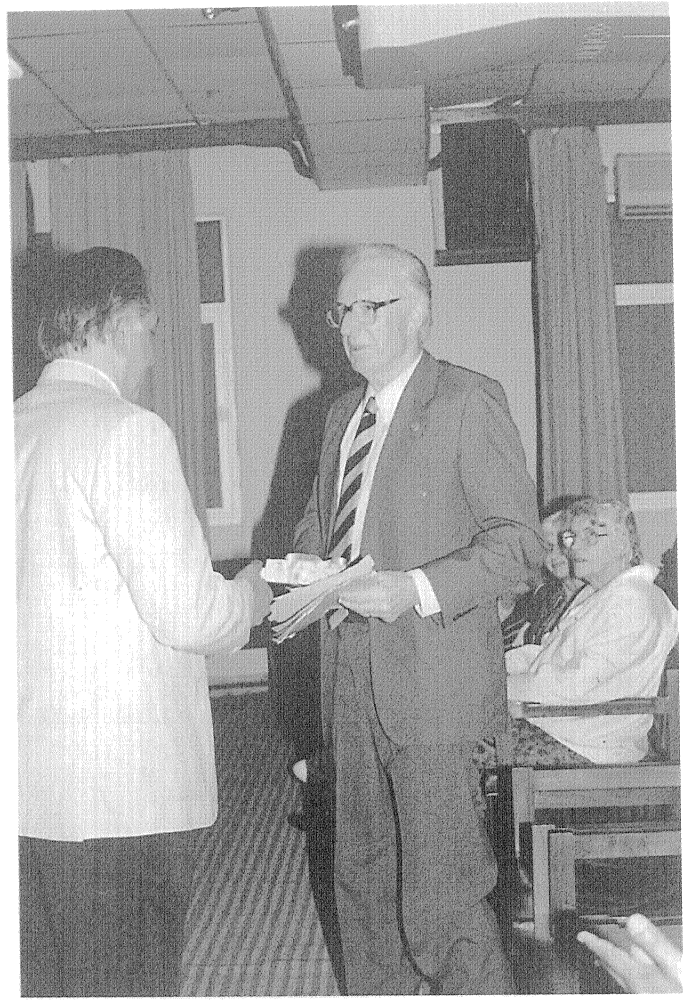
Prof. V.S. Ramamurthy, B.V. Sreekantan and R. Cowsik, at the time of dedication of IAO, Hanle on 29th Aug 2001.

NGC 1637, taken with the Himalayan Chandra Telescope



The Indian Academy of Sciences Public Lecture "The Search for Intelligent Life" was given by Professor Sir Arnold W Wolfendale, F.R.S. (centre) at the Institute on Jan 3, 2002.

Prof. H. Narasimhaiah, among others attending the lecture give by Prof. Wolfendale.



Prof. Wolfendale (right) with Prof. R. Cowsik.

SCIENTIFIC RESEARCH

Solar physics

MHD pulsations of the sun

Solar/stellar magnetic cycles and activity phenomena are some of the outstanding unsolved problems in astrophysics. In case of the sun it is believed that dynamo mechanism may be operating near the base of the convective envelope which may be responsible for the maintenance of solar cycle and activity phenomena. Though traditional mean field dynamo theories explain some of the observed solar cycle and activity phenomena, many outstanding problems such as amplitudes and widths of the butterfly diagram, irregular periods in the sunspot cycle, the observed long period (~ 22 yrs) power spectrum of the solar magnetic field, disparity in the amplitudes of solar magnetic and torsional rotational perturbations etc., remain to be explained. Aim of the present study is to solve these problems consistently step by step.

Deviating from the traditional mean field dynamo theories, we consider solar magnetic and activity cycles as manifestations of long period global MHD pulsations over the underlying steady parts of magnetic and velocity fields. In order to achieve our goal we adopt Chandrasekhar's (1956, ApJ, **124**, 231) HD equations in the frame work of axisymmetric, incompressible viscous fluid for the solar/stellar convective envelope. By taking a clue from the sun that perturbations in meridional velocity and poloidal part of the magnetic field are negligible compared to the perturbations in toroidal part of the magnetic field and rotational velocity and, by using the solutions of basic steady parts of magnetic (Hiremath and Gokhale, 1995, ApJ, **448**, 437) and velocity fields (Hiremath, 2001, BASI, **29**, 169), we compute perturbations in the toroidal part of the magnetic field (superpositions of which are supposed to be solar/stellar spots) and rotational velocity. Preliminary results show that the perturbations in magnetic and rotational velocity fields either grow or dampen after one or two solar/stellar rotations depending upon the initial and boundary conditions. This important result leads us to include a force term due to effect of a periodic perturber of an unknown origin in the perturbed induction and momentum equations in order to maintain solar/stellar magnetic and rotational pulsations.This work is in progress.

(K. M. Hiremath)

Influence of the solar activity on the Indian monsoon rainfall

We continued the study of the influence of solar activity on the Indian monsoon rainfall and the results are as follows. We used 120 years data for studying correlative effects due to solar cycle and activity phenomena on the occurrence of Indian monsoon rainfall activity. For the raw and smoothed data of each solar cycle, we compute the correlation coefficients and significance of correlation coefficients for the seasonal months of Jan–Feb (J+F), March–May (MAM), June–September (J-S) and October–December (OND). We find that : (i) with a moderate-to-high significance, Indian monsoon rainfall activity is correlated with the sunspot activity, (ii) there is an overall trend that during the period of low sunspot activity, occurrence of rainfall activity is high compared to the period of high sunspot activity and, (iii) from the year 1871 onwards, there is a long term trend indicating a gradual decrease of occurrence of rainfall activity by nearly 1 mm/yr and increase of sunspot activity by nearly 6 sunspots/yr compared to the activity of the previous solar cycle.

We speculate, in this study, a possible physical connection between the occurrence of the rainfall and the sunspot activities and the flux of galactic cosmic rays.

(K.M. Hiremath and P.I. Mandi*)

Axisymmetric MHD fluids with density stratification

We investigated the axisymmetric MHD fluids with density stratification and results are as follows.

With the density stratification and anelastic approximation, following Chandrasekhar (1956, ApJ, **124**, 231), we derive four sets of simultaneous axisymmetric MHD equations. For the special case of infinite electrical conductivity and stationary fields, the resulting Ferraro's law of isorotation is same as the law of isorotation derived from the incompressible and axisymmetric MHD equations. On the other hand, equipartition of energy between angular velocity and toroidal part of the magnetic field does not hold good in case of the fluid with the density stratification.

(K.M. Hiremath and V.V. Pipin*)

Solar activity : Dynamics of the large-scale unipolar magnetic regions on the Sun

We had used the H-alpha synoptic observations of Kodaikanal and Kislovodsk and studied the evolution of the large-scale unipolar magnetic regions on the sun and the dynamics of the polar field reversals covering a period of nearly 8 solar cycles (1910 - 1990). The basic tenet of these investigations is that the filaments in the H-alpha images of the sun represent the magnetic neutral lines and so by tracing the movements of the filaments, the migration of the magnetic fluxes on the solar surface can be inferred. This has helped to study the evolution of the global magnetic fields as far back as 1910 when the solar magnetograms did not exist.

We brought out for the first time that a component of solar activity appears at the high latitudes on the sun soon after the magnetic field reversal at the poles and demonstrated that this high latitude component is a precursor to the conventional acitivity at the lower latitudes (viz.the sunspot activity) and their role in the 22-year magnetic cycle.

(K.R. Sivaraman, V.I. Makarov* and A.G. Tlatov*)

Large-scale magnetic fields on the sun

In a recent study we have extended the polar reversal study to the solar cycles 22 and 23 (1985 - 2000) and also examined the rate of the poleward migration of the equatorial fluxes in relation to the total flux contained in the sunspot latitudes using the H-alpha synoptic maps for 8 solar cycles constructed by us. The polemost filament bands in the north and south hemispheres migrate towards their respective poles and ultimately cause the polar reversal. The filament bands just below the polemost ones also migrate and reach latitudes 35 - 45 deg by the time of the polar reversal and become the polemost once the reversal is over. The migration to the poles starts (at a low speed of 3 m s^{-1}) only when the spot activity has risen to a significant level and then suddenly accelerates to 30 m s^{-1} at the peak of activity. We quantify this possible cause and effect phenomena by introducing the concept of the "strength of the solar cycle" and represent this by either of a set of three parameters. We show that the speed of poleward migration of the filament bands (and hence the magnetic flux) is linear function of the "strength of the solar cycle".

(K.R. Sivaraman, V.I.Makarov* and A.G.Tlatov*)

Solar rotation

We have been able to find a possible solution that would settle the long standing controversy over the two different rotation profiles on the sun starting from the equator all the way to the poles by two groups: one that shows a steep differential rotation similar to that for the surface plasma and the second, opposing one that shows a rigid rotation for the same latitudes both using essentially the same magnetogram data. Using fresh results from polar rotation measurements, we have been able to show that the steep differential rotation results from contributions by small and medium spatial features, while the rigid rotation profile and analysis samples the large scale unipolar regions

which are deep rooted and so reflects the rigid rotation of the plasma at the deep interior.

(K.R.Sivaraman and M.H.Gokhale)

Dynamics of K_{2v} bright points

There is an ongoing investigation to study the dynamics of the K_{2v} bright points using fresh research material acquired at the Solar Vacuum telescope at the Sacramento Observatory.

The aim is to detect the signatures of the waves with different periods (particularly the very short period ones in the range of 10 to 60 sec) that are suspected to be present in the chromosphere and transport energy upwards. In addition to the study of the evolution of the K_{2v} bright points, we have examined the evolution of regions in between the bright points. We find that these regions show oscillations with 300 sec periodicity. We interpret this as the source for the basal heating of the chromosphere.

(K.R.Sivaraman and Usha Shekar*)

Polar activity and magnetic field reversal in the current solar cycle 23

The global solar cycle is considered as a manifestation of 3 types of magnetic activity: polar, sunspots and the large scale magnetic fields. We present the properties of the polar activity cycle at latitudes higher than 40 deg using the data on polar faculae, bright magnetic regions seen in SOHO images and magnetic neutral lines from the H-alpha synoptic maps constructed by us. We notice that the polar activity cycle is not dependent on the sunspot activity.

(K.R. Sivaraman, V.I.Makarov* and A.G.Tlatov*)

Long-term variations in solar differential rotation

Using Greenwich data on sunspot groups during 1879—1975 we determined solar cycle-to-cycle variations in the coefficients of solar differential rotation (see Figures 1(a) and 1(b)). We found the following results :

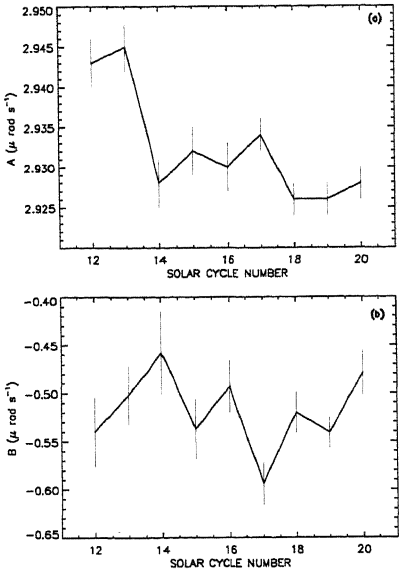


Figure 1 : Cycle-to-cycle variations of *A* and *B*. Northern and southern hemispheres data are combined. *A* and *B* are coefficients in the standard form of the solar differential rotation $\omega(\lambda) = A + B\,sin^2\lambda$, where $\omega(\lambda)$ represents sidereal rotation rate at latitude λ.

(i) The trend of the cycle–to–cycle variation of the equatorial rotation rate (A) suggests existence of a long periodicity of the order of 100-yr in A; (ii) Existence of ~ 66-yr cycle (Gleissberg cycle) is seen in the cycle–to–cycle variation of the latitude gradient (*B*). A weak 22-yr modulation in *B* seems to be superposed on the relatively strong 66-yr modulation; and (iii) It seems the well known Gnevyshev and Ohl rule (Gnevyshev and Ohl, 1948) of solar activity is applicable also to *B*.

(J.Javaraiah)

Relationship between magnetic structures of small and large sunspot groups

Earlier, using Greenwich data on sunspot groups during 1874–1939 we studied dependence of mean rotation frequency of a spot group on its age (t) and dependence of 'initial rotation frequency' of a spot group on its life span (τ). These were compared with the dependence of plasma rotation frequency ($\Omega(r, \lambda)$) on the radial distance (r) and latitude (λ) as determined from helioseismology. From this we obtained the following relations (Javaraiah & Gokhale 1997, A&A **327**, 795):

$$r(t) = (480.6 \pm 0.7) + (20.9 \pm 0.1)\, t \qquad (1)$$

for the spot groups of life spans 10–12 days in latitude 10°–20°; and

$$r_0(\tau) = (696.5 \pm 0.6) - (20.9 \pm 0.1)\, \tau \qquad (2)$$

for the spot groups of life spans 2–12 days in the entire sunspot latitude belt. Here $r(t)$ and $r_0(\tau)$ are in Mm and the $t_0(\tau)$ represents 'initial anchoring' depths of the magnetic structure (flux ropes) of spot groups of life span τ. These relations imply the following possibility: (i) the magnetic structures which yield spot groups with life spans 10–12 days are initially anchored near the base of the convective envelope; (ii) in latitudes 10°–20° these structures rise at a rate ~ 21 Mm per day, as the spot group ages; and (iii) the magnetic structures of spot groups which live successively shorter by 1 day are also initially anchored in layers successively shallower by ~ 21 Mm.

Now we have analyzed the upgraded Greenwich data during 1874–1976. The relation (1) above, is found to be more realistic for spot groups with average area $A \geq 130$ millionth of the solar hemisphere (corresponding magnetic flux, $\Phi \geq 10^{22}$ Mx). For spot groups of life span 2–12 days we found that:

$$A(\tau) = 15.24\, exp(\tau/4.48) \qquad (3)$$

and

$$N(\tau) \sim 2824 \exp(-\tau/5.38)\,. \qquad (4)$$

The magnitudes of the slopes in equations (1) and (2) above, are equal. It follows that for spot groups with $\tau \leq 9.5$ days

$$r_0(\tau) \approx r(10.5 - \tau)\,. \qquad (5)$$

This means that in latitudes 10°–20° the 'initial anchoring' of the magnetic structures of spot groups with $\tau \leq 9.5$ days is at the same depth where the anchoring of the magnetic structures of spot groups with life span $\tau = 10.5$ days rises in $t = (10.5 - \tau)$ days. Also, the equations (2) and (3) imply the exponential relation:

$$A \approx 130\, exp(-H/95)\,, \qquad (6)$$

where H, in Mm, is the height above the base of the convection zone. From these two facts we have drawn the following tentative inferences: (a) magnetic structures with magnetic flux $\Phi \geq 10^{22}$ Mx might be generated around base of the convection zone, (b) many of the magnetic structures may be fragmenting (or branching) into smaller structures while rising through the solar convection zone, and (c) magnetic structures with $\Phi < 10^{22}$ Mx might be the fragmented (or branched) parts of the larger magnetic structures. These inferences are consistent with the proposals of some theoretical models (e.g., Parker 1979, ApJ **232**, 282).

(J.Javaraiah)

Kink and longitudinal oscillations in the magnetic network

We examine the propagation of kink and longitudinal oscillations in the solar magnetic network. In earlier work we investigated the excitation of network oscillations in flux tubes through the buffeting action of external granules. These results, which showed that the footpoint motions of flux tubes can generate sufficient wave energy for chromospheric heating, assumed that: (a)

the waves could be treated using the linear approximation, and (b) the kink and longitudinal waves were decoupled. These approximations, although valid in the lower atmosphere, break down in the upper chromosphere, where the wave amplitude becomes comparable with the tube speed. We overcome the earlier limitations by numerically solving the nonlinear MHD equations for coupled kink and longitudinal waves in a thin flux tube extending vertically from the sub-photosphere to the base of the corona. Our code is able to resolve shocks and also treats energy transfer between modes self-consistently. We find that kink waves generated due to footpoint motions of the flux tube, generate longitudinal modes due to mode coupling. This coupling is solely due to nonlinear effects and for subsonic velocities, the longitudinal wave amplitude increases quadratically with the transverse wave amplitude. For wave amplitudes close to Mach number unity (with respect to the kink wave speed), there is almost equipartition of energy between the two modes. We calculate the energy flux in vertically propagating waves and discuss their role in heating the chromosphere and possibly the corona.

(S.S. Hasan, W. Kalkofen*, A.A. van Ballegoiijen* and P. Ulmschneider*)

Convective intensification of magnetic flux tubes in stellar photospheres

The convective collapse of thin magnetic flux tubes in the photospheres of sun-like stars is investigated using realistic models of the superadiabatic upper convection zone layers of these stars. The strengths of convectively stable flux tubes are computed as a function of surface gravity and effective temperature. We find that while stars with $T_{eff} \geq 5500$ K and $\log g \geq 4.0$ show flux tubes that are highly evacuated of gas, with strong field strengths due to convective collapse, cooler stars exhibit tubes with lower field strengths. Observations reveal the existence of field strengths close to thermal equipartition limits even in cool stars, implying highly evacuated tubes. We offer a physical explanation for this phenomenon.

(S. P. Rajaguru, R. L. Kurucz* and S. S. Hasan)

Physical limits on the magnetic field strengths of starspots

The maximum magnetic field strength that a starspot can exhibit is intimately related to the thermal conditions at the observable level of the Wilson depression inside the starspot atmosphere. Using Kurucz (1993) atmospheric models and Rosseland mean opacities from Kurucz and Alexander & Ferguson (1994), we examine the thermal-magnetic relation to obtain magnetic field strengths and values of the Wilson depression as a function of effective temperature T_{eff} and surface gravity g of a star.

(S. P. Rajaguru and S. S. Hasan)

Chromospheric activity : Variability of CaII K emission flux over the solar cycle

We have analyzed, high spectral resolution CaII K line profiles obtained in integrated Sun light (Sun as a Star) from a scatter free system, Double Pass Spectrograph, of the Indian Institute of Astrophysics, Bangalore for the period 1989 - 1993. The various parameters of the K-line profiles have been extracted. The total K-emission flux centered around 1Å pass band has also been derived from all the line profiles. This flux has been compared with 1Å K Index of NSO/Sac Peak and UV irradiance measured in MgII h & k lines, and found that they are well correlated with each other. It would enable us to construct a model of the chromosphere using the line profile parameters and would serve as a reference for inferring the chromospheric variations in other Sun-like stars as a function of stellar activity.The analysis is in progress.

(R. Kariyappa and K. R. Sivaraman)

On the disappearance of H-alpha filaments and soft x-ray enhancements as seen from Yohkoh SXT

We have studied H-alpha images of the sun taken at Kodaikanal and Mitaka observatories and soft X-ray images obtained by SXT

onboard *Yohkoh* for the years 1993 and 94. From events of disappearing quiescent H-alpha filaments and associated soft X-ray brightenings we found that in some cases H-alpha filament appears broken and diffused about a day earlier than the beginning of the soft X-ray enhancement and it disappeared completely during the event of soft X-ray transient brightening which lasted for 7 - 10 hours. Further, enhancements began along filament channels and then moved along arches which were inclined to the filament direction. From these observations we postulate that heating of plasma in the filament begins when it appears broken and less dark and continues till it triggers some physical process, responsible to begin soft X-ray enhancement. It is not possible to say that if the H-alpha filament disappears earlier than the beginning of soft X-ray enhancement or vice versa as there is time difference between H-alpha and soft X-ray observations.

(Jagdev Singh, T.Sakurai* and K.Ichimoto*)

Dependence of supergranular length-scales on network magnetic fields

In an earlier paper by Raju et al. (1998) (Paper I), average size of chromospheric network cells has been shown to have a dependence on the solar latitude. This was presumed to be due to the reduction of supergranual length-scales by network magnetic field enhancements. It has been found that the network brightness enhancements over solar latitude support this finding. Significant negative correlations have been found between the average cell size and the network brightness enhancements. Since the brightness enhancements are essentially due to the magnetic field concentrations, it is suggested that the network magnetic fields reduce the network cell sizes. We have also obtained the variations of skewness of network brightness distributions over solar latitude, which follow the network field variations. This complements the findings of Caccin et al. (1998) that skewness of brightness distribution follows the solar cycle. The findings suggest that the dependence of supergranular sizes, network brightness, and skewness of network brightness distribution on solar latitude or on the phase of the solar cycle is due to the associated variation of network magnetic fields.

(K.P.Raju and Jagdev Singh).

Spectroscopic studies of the solar corona : Spatial and temporal variations of intensity ratio of infrared lines of Fe XIII in the solar corona

We have obtained the spectrographic observations of several coronal regions in three emission lines 6374 Å [Fe X], 10747 Å [Fe XIII] and 10798 Å [Fe XIII] simultaneously with the 25 cm coronagraph at Norikura Observatory using two large format CCD cameras on several days. The image scale on the spectrum was about 2″ per pixel and the slit width of 160 microns provided a spatial resolution of 4″. The infrared spectra were recorded with a resolution of 121 m Å per pixel. The peak intensity, velocity and line-width values were derived from the Gaussian fit to the observed line profile at each location of the observed coronal region of about 200 ″ x 500″ size. The ratio of intensities of 10747 Å and 10798 Å emission lines in the individual coronal structures range between 1.0 - 2.5 at 10″ above the limb which corresponds to a density range of 9.8×10^9 - 2.4×10^8. Scale-height temperture values, derived from the variations of the intensity ratio with height above the limb for all the individual coronal structures, range between 0.6 - 8.3 x 10^6 K with a most frequent value around 1.8×10^6 K. The large values of scale-height temperature for 70 percent of the structures indicate that these structures may not be in hydrostatic equilibrium and isothermal in nature.

(Jagdev Singh, K.Ichimoto*, T.Sakurai* and A.Takeda*)

Spectroscopic studies of the solar corona : Physical properties of coronal structure

We have obtained the spectrographic observations of several coronal regions in the green (5303 Å) and red (6374 Å) emission lines simultaneously on

several days with the 25 cm coronagraph at Norikura Observatory using two large format CCD cameras. On some other days similar observations were made which covered three coronal emission lines 6374 Å [Fe X], 10747 Å [Fe XIII] and 10798 Å [Fe XIII] simultaneously. The slit width of 160 microns provided a spatial resolution of 4″ and spectral resolution of 77 mÅ at the green line, 128mÅ at the red and 291 mÅ at the infrared lines. The width, intensity and Doppler shift for all these lines were computed using Gaussian fits to the observed line profiles. The range of intensity ratio observed between the green and red lines implies a temperature of coronal structures between 1.2 and 1.8 x 10^6 K. The line-width measurements indicate that in almost all the coronal structures, the FWHM of the red line increases with height above the limb with an average value of 1.24 m Å/arcsec, while that of the green line decreases with height with an average value of 0.66 mÅ/arcsec. Whereas the FWHM of infrared lines decreases with height above the limb in only half of the individual coronal structures and increases in the remaining coronal structures. The magnitudes of FWHM gradient with height for the infrared emission lines is marginal as compared to the green and red lines when normalised to the respective wavelengths. These imply that change in FWHM of coronal emission lines with height depends on the ionization temperature of the line and is negative for relatively high temperature lines. This kind of behaviour of change of FWHM of lines with height rules out the existence of propagating waves in the coronal structures. The anti-correlated variation in FWHM of the green and red lines and negligible variation in FWHM of infrared lines with height above the limb can be explained by assuming the mixing of plasma in the middle and higher parts of coronal structure through microturbulence.

(Jagdev Singh, K.Ichimoto*, T.Sakurai* and S.Muneer*)

Digitization of broad band images of the sun obtained at Kodaikanal

The Indian Institute of Astrophysics and Japanese Science and Technology decided to jointly digitize the broad band images of the sun obtained at Kodaikanal for about 98 years and use the data to study variation in solar irradiance and its effect on earth's climate, differential rotation of sun and other features related with sunspots. It took about one year to install and test the two digitizers using 4k x 4k CCD cameras. One meter lab-sphere with uniform and constant intensity has been used as a light source to illuminate the photographic plate or film. The image of the sun is about 200 mm. The CCD camera uses cryo system for cooling, providing a low dark current and low noise. The data is read at a speed of 200 KHz using 16-bit digitizer card. The image of about 32 MB is stored in FITS format. We take the dark and flat field image about every hour. Finally the data is being stored on DLT tapes. Images of the sun obtained in the month of January each year have been digitized so far.

To correct for the optical aberrations in the images obtained since 1904, Yoshimura proposed to fabricate and install a pinhole telescope using 4k x 4k CCD camera as a detector. A tube of about 4.5m length with a pinhole of 2.5 mm aperture has been used to form the solar image on the CCD detector. Trial image of the sun using this pinhole telescope and existing 15 cm telescope have been obtained simultaneously. These images need to be analysed to compute the factors responsible for the optical aberrations in already obtained solar images.

(Jagdev Singh, S.S.Gupta and H.Yoshimura*)

East-west asymmetry in properties of sunspots

There have been occasional reports of asymmetry in the observed properties of sunspots between the eastern and western solar hemispheres. The rates of occurrences of the classic Wilson effect, the no Wilson effect or the reverse Wilson effect cases seem to differ in the two hemispheres. Besides, it is reported that the limbward to diskward penumbral width ratio — a measure of the Wilson effect, shows asymmetry in the two hemispheres. We have examined this aspect in detail, using our Kodaikanal observations and the Solar Geophysical Data. It turns out that the asymmetry in rates of occurrence is

marginal to significant, depending on the selection criteria and the duration of observations. Further, an interesting result emerges that the east-west asymmetry is significant and consistent in the single isolated unipolar epochs. The penumbral width ratio decreases steadily from eastern to western hemisphere. We demonstrate that the decrease is associated with the gradual decay of the sunspot. The property of decrement is, however, sensitive to changes in the surrounding magnetic topology.

(S.P.Bagare and S.S.Gupta)

The missing flux problem in sunspots

One of the classic problems in sunspot studies pertains to low temperatures in umbrae. There are competing theories to explain the observations ; one that expects an efficient removal of heat and the other that proposes the blocking of the energy in sub-photospheric layers. The theories also predict the presence of bright rings around sunspots. In occasional cases, observations of bright rings have been reported. These rings, if present, will account for a part of the missing flux. We have started studying many cases to decipher whether or not the bright rings occur in all sunspots. The initial results show that the rings appear only in a particular magnetic category of sunspots. We have taken up detailed study of the associated behaviour in the chromosphere, using the Kodaikanal spectroheliograms and photoheliograms. We are also examining the high resolution MDI data for this study.

(S.P.Bagare and Rabbi Angiras*)

Solar data exchange program

We continued this year to provide the photoheliogram copies for the 'missing days,' to the Debrecan Solar Observatory in Hungary. The Observaory has started publishing the sunspot data on a regular basis, and the contributions of the participating observatories are acknowledged in these publications.

(S.P.Bagare)

Spectroscopic parameters for astrophysically important molecules

Estimation of Franck-Condon factors or the transition probabilities and the dissociation energies for select transitions of various molecules of astrophysical importance has been taken up. The presence of these molecules is reported in the low temperature surroundings of sunspots and in many late type stars. The recently published umbral spectra identify many diatoms while many other bands remain unidentified. These spectroscopic parameters are necessary for relative abundance estimates and for the identification of the emitting/absorbing species.

(S.P.Bagare and N.Rajamanickam*)

Measurement of solar vector magnetic fields using the Kodaikanal tower telescope

A Stokes polarimeter was built at the Kodaikanal Tower Telescope to study the vector field map of active regions like sunspot using the well known Fe I lines 6301.5 Å and 6302.5 Å lines. The Mueller matrix of the polarimeter was obtained using simple laboratory and field tests. The instrumental polarization due to the oblique reflections are removed before the observed Stokes profiles were analyzed. The Advanced Stokes Polarimeter data analysis program (ASP code) was used to invert the corrected Stokes profiles to calculate the vector magnetic field parameters of NOAA 8951. The maximum field strength obtained at the umbra of the sunspot was 2500 Gauss. The variation of the field strength, the line-of-sight angle and the azimuthal angle along a cut which passes through the umbra resembles that of a simple round sunspot. The accuracy in the calculation of the vector field is high in the umbra and low in the outer edge of the penumbra of the observed sunspot. The range of errors in the calculation of the field strength, line-of-sight inclination angle, and the azimuthal angle of the magnetic vector are 20-100 Gauss, 1-5°, and 12-20° respectively. We also find a good fit for the observed

Stokes profiles of the Ti I line at 6303.78 Å with a synthetic profile produced using the vector field parameters derived from the Fe I 6301.5 Å and 6302.5 Å lines.

(K.Sankarasubramanian, K.E.Rangarajan and K.B.Ramesh)

Microwave radiometric retrieval of temperature inversion parameters

Temperature inversion near the earth's surface in the troposphere is usual during winter and night time conditions. The low level inversion can act as a 'lid' which traps pollution laden air beneath it. The study of inversion is important because the natural and man-made aerosols cause poor visibility below the inversion layer while above the inversion layer, the visibility is good.

In this study, we explore the possibility of retrieving the parameters that specify the temperature inversion using ground based radiometric measurements. A parameterized radiative transfer model is used to quantify the microwave radiation in 12 frequencies spanning the *K* and *V* bands. The sensitivity of the downwelling brightness temperatures to Liquid Water Path (LWP), total water vapor, the amount of temperature inversion, height of the inversion layer, etc are made. The sensitivity study allows us to construct physically based retrieval models for obtaining parameters such as (i) the amount of inversion and (ii) the height of inversion layer.

(K.E. Rangarajan and J.Vivekanandan*)

Study of polarised radio emission from the solar corona

Mechanical and hardware work is being carried out for the setting up of a new antenna system for the measurment of polarisation of the transient radio emission from the Sun both near and at large distances from it (the latter through observations of the occultations of different discrete cosmic sources by the solar corona). The data obtained is expected to reveal useful information on the magnetic field in the outer solar atmosphere ($\geq 0.3\ R_\odot$ above the photosphere limb [$R_\odot$ = radius of the Sun = 6.96×10^5 km]

(R.Ramesh, C.Kathiravan, M.S.SundaraRajan and K.R.Subramanian)

Observations of pre-event signatures of transient explosive events from the solar atmosphere

One of the primary goals of the Gauribidanur radioheliograph (GRH) is to try and detect weak, pre-event signatures of the onset of a coronal mass ejection (CME). The latter is an explosive event in the solar atmosphere during which material weighing about 10^{15} grams is ejected into interplanetary space at speeds of the order of 1000 km/s. An early warning of these mass ejections could prove useful since they can affect radio communications, electrical power systems and satellites orbiting the Earth. We tried to address the above problem using a particular class of discrete, radio emitting source on the Sun called 'noise storm'. We specifically selected the latter for our investigation since they are closely associated with the changes in the photospheric magnetic field. One of the theories postulated for the onset of a CME is interaction between the field lines of newly emerging magnetic flux from beneath the solar photosphere and old, existing active regions of opposite polarity. There also seems to be a similarity in the source regions of the CMEs and the noise storms; (i) most of the regions with spot areas above ~ 200 millionths of the solar disk show noise storm association as well as sigmoid-to-arcade evolution of structures which in turn are related to the 'halo' CMEs (the latter take place close to the central meridian of the Sun on its visible hemisphere and are supposed to travel straight towards Earth), and (ii) both the CMEs and noise storms are preferentially associated with multipolar magnetic systems. In view of the above, we carried out a statistical study of the metric noise storms and the CMEs to determine the temporal/spatial association between them. The CME data reported were taken from the list based on the observations with the Large Angle and Spectroscopic Coronagraph (LASCO) onboard the Solar and Heliospheric Observatory (SOHO), during the period

from January 1997 through June 1998. We specifically selected the above period because of the following reasons:(i)two-dimensional radio data giving the location and the precise start time of the noise storm sources is available only from January 1997, and (ii) it forms a subset of the first period of uninterrupted operation of SOHO,i.e.,from January 1996 through June 1998,and a complete list of the white light CMEs observed with the LASCO are available. Here again,to establish an unambiguous identification,only 'non-halo' CME events,and noise storm sources located close to/off the solar limb were considered for the present study. Out of the 12 noise storms which met

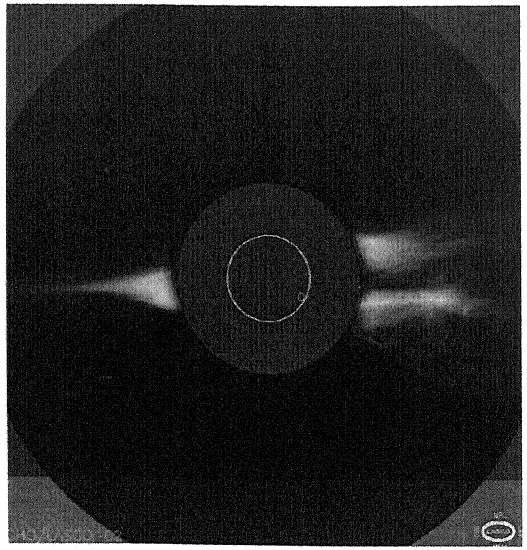


Figure 2 : Composite image showing the CME event observed with the Large Angle and Spectrometric Coronagraph (LASCO) onboard the Solar and Heliospheric Observatory (SOHO) on April 13, 1997 (the 'bulb' shaped feature above the occulting disk in the South-West quadrant), and the location of the noise storm continuum observed on that day. The latter was observed about 6 hrs prior to the eruption. One can clearly notice that the centroid of the noise storm continuum (marked 'o') is located within the angular span of the CME. The other bright features in the white light image are preexisting, long lived streamers. The open circle at the center is the solar limb and the outer bigger circle is the occulting disk of the coronagraph, located at approximately 2.2 R_{sun} from the center. Solar north and east are straight up and to the left, respectively.

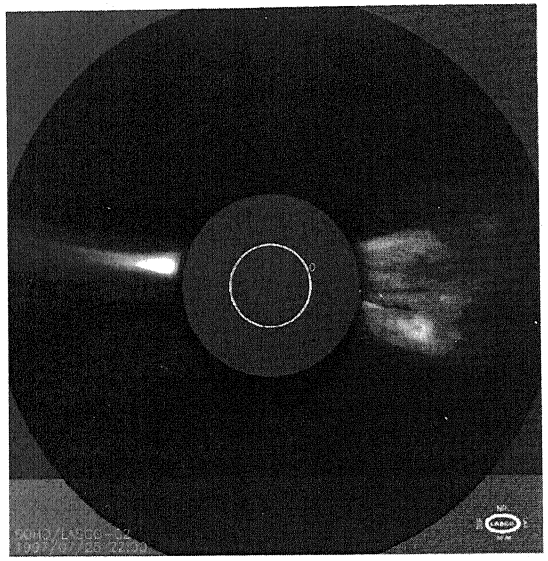


Figure 3 : Same as in Figure 2, but observed on July 25, 1997. The bright complex white light feature in the West quadrant is the CME event.

the above requirements, 10 events were temporally followed by a CME. The time delay varied from about 1 to 14 hours. Also they were located within the angular span of the latter (Figure 2 & 3). This is a significant advancement in the prediction of CMEs since one uses ground based data.

(R.Ramesh and G.A.ShanmughaSundaram)

New results on flare associated shock waves from the Sun

One of the long-standing controversies of solar and solar-terrestrial physics involves the origin of the shock waves in the solar corona that manifest themselves as Type II radio bursts. The emission is attributed to shock-accelerated electrons that excite plasma waves that convert into escaping radio waves. At various times during the past fifty years, Type II associated shock waves have been attributed either to solar flares or to CMEs, or to some

combination of the two phenomena. The association between Type II bursts and shocks is rather complex, in particular in the corona where flares and CMEs occur jointly. Using the data obtained with the digital spectrometer operating at the Gauribidanur Radio Observatory and the Large Angle and Spectrometric Coronagraph (LASCO) on board the orbiting Solar and Heliospheric Observatory (SOHO), we found that the shock waves originating from a flare site also give rise to transient absorption radio bursts, at times (Figure 4 & 5).

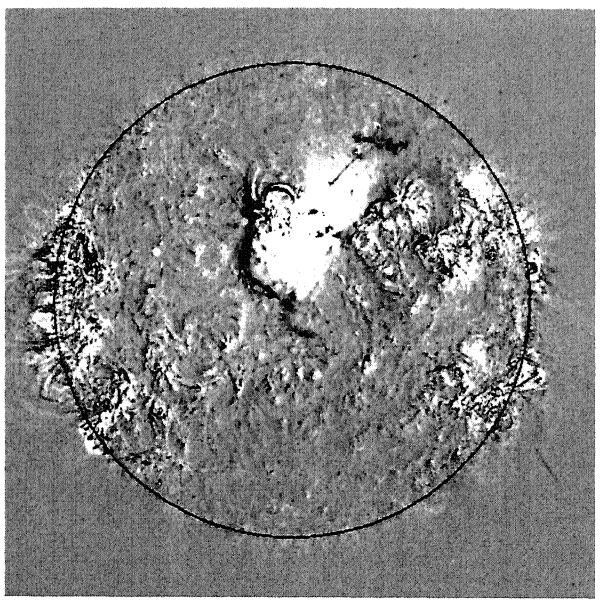


Figure 4 : Difference image (05:11-04:15 UT) of the X2.0/3B flare observed on November 24, 2000 with the Extreme-ultraviolet Imaging Telescope (EIT) onboard SOHO at 195 Å. The bright region near the center is the flaring region and the dimming regions correspond to material depletion in the aftermath of the CME. The outer black circle is the solar limb.

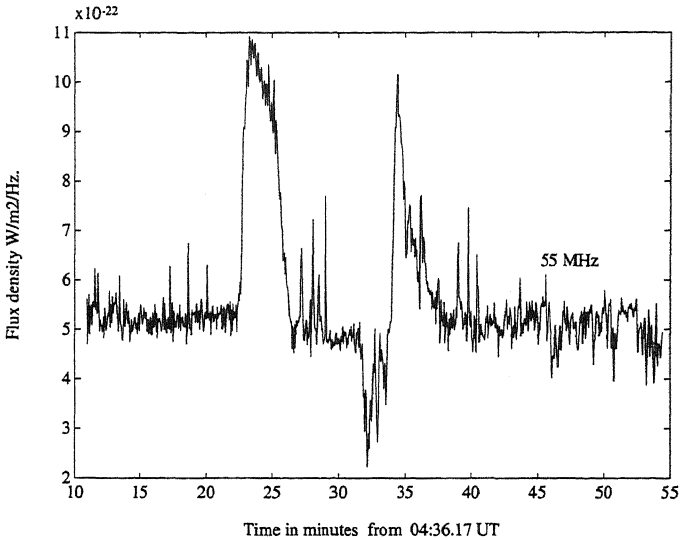


Figure 5 : Time profile of the emission/absorption burst (s) observed on November 24, 2000 at 55 MHz in the time interval 04:45-05:30 UT. One can notice that there is a good temporal correlation between the absorption burst (05:09 UT) and the dimming regions in Figure 3. The emission burst (05:01 UT) probably corresponds to the main flare activity prior to the launch of the CME.

It is possible that this might turn out to be an independant observational evidence for investigating the presence of shock waves in the solar corona and its association with flares and CMEs

(R.Ramesh and E.Ebenezer)

Metric radio observations and ray tracing analysis of the onset phase in solar eruptive event

Most of the current observations of CMEs are from coronagraphs which detect them in Thomson scattered sunlight above its occulting disk. The occulter of the coronagraph generally covers both the solar disk as well as the inner corona ($\leq 1.3\ R_{\odot}$).

Hence the white light observations have the inherent difficulty in providing information about the early evolution of CMEs. A study of the near surface onset phase of a CME is considered to be very important since the basic physical state of a CME is completely determined at its initiation. Its subsequent development during the transit through the heliosphere is just an evolutionary process. In this respect, imaging observations at radio wavelengths play an important role since they do not have the limitation of an occulting disk and the CMEs can be detected early in their development via the thermal bremsstrahlung radiation they emit. Also one can observe activity at any longitude similar to X-ray and EUV wavelengths. Again the frontal structure of a CME has a large optical depth at meter wavelengths, and can be readily observed. In this situation, we carried out detailed analysis of the onset phase of the giant and massive CME event of June 2, 1998 using the radio images of the solar corona obtained with the Gauribidanur radioheliograph (Figure 6).

The electron density, mass and volume were estimated by successfully modelling the observed two-dimensional radio brightness distribution, for the first time. The values agree well with those published in the literature using spaceborne white-light coronagraphs.

(C.Kathiravan, R.Ramesh and K.R. Subramanian)

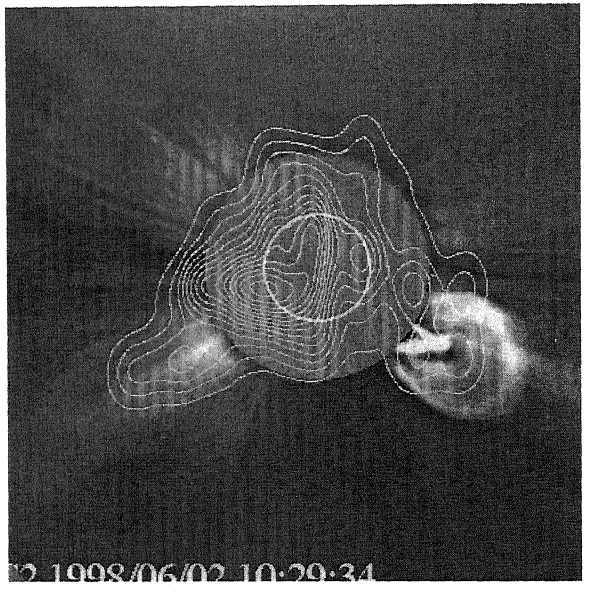


Figure 6 : Composite picture showing the LASCO image of the giant prominence eruption observed on June 2, 1998 and the radio brightness distribution of the Sun at 109 MHz obtained with the Gauribidanur radioheliograph. There is an excellent spatial correspondence between the bright features in the white light image and the radio enhancements off the limb. The bright feature in the South-West quadrant of the white light image is the prominence eruption. The open circle at the center is the solar limb. The outer circle is the occulter of the coronagraph. It extends approximately upto 2.2 $R_{\odot}$ from the center of the Sun.

Solar system studies

Asteroid occultation

Analysis of occultation of the star HIP 66446 by 423 Diotima on 15 March, 2001 from three stations

Observations of the occultation of the star HIP 66446 by 423 Diotima on 2001 March 15, made by the team at the Vainu Bappu Observatory and two mobile teams at Ganeshgudi and at CES Field Research Station at Sirsi were jointly analysed. The observations at Ganeshgudi by the IUCAA team were video-recorded using a CCD based web-camera attached to the eye-piece holder of a portable Schmidt-Cassegrain telescope of 35 cm aperture. The observations at the CES FRS by the second team from IUCAA were carried out using a portable Schmidt-Cassegrain telescope of 20 cm aperture and a focal length of 2000 mm. An eye piece of 40 mm 1.25 barrel was used for visual timing. From the limited data, we make a preliminary estimate of 186 km x 149 km for the projected size of the asteroid. The projected short axis is found to be tilted to the North by 59°. The immersion and emersion events occurred in two stages revealing the binary nature of the star for the first time. The derived integrated brightness ratio of the stars from the two step immersion and the emersion events is found to be 1.33 ± 0.27. The projected separation between the two components along the track, *i.e.* along the direction 115° from North, is found to be 28 km or 0.018 ± 0.002 arcsec.

(R. Vasundhara, B. K. Jayakumar, C. Velu, M. Appakutty, A. Paranjpye*, H. Kulkarni*, P. Nitsure*, M. Prabhunne* and K. Shah*)

Astrometry from CCD photometry of mutual events of Jovian satellites from VBO during 1997

The Galilean satellites occult and eclipse each other twice during the orbital period of Jupiter of about 11.6 years. The astrometric results of mutual events provide accuracies of the order of 0.03 arcsec and hence have great potential in studies of secular variations in mean motion of the satellites. The astrometric information was extracted from the light curves obtained from VBO by incorporating the albedo mosaics of Io and Europa constructed from Galileo images by Geissler et al. (Icarus **140**, 265, 1999) and Phillips et al. (LPSC XXVIII 1103, 1997) respectively in our model. The derived (O-C) in longitude and the differential coordinates of the pairs of satellites for the 1997 events were estimated which can be directly utilized in future studies to update the constants of motion of the satellites. The present investigation indicates that the (O-C) in longitude with respect to the latest set of ephemerides E5 (Lieske, J.H., A&AS **129**, 205) for the events in which Ganymede eclipsed or occulted Europa, are found to be higher than those with respect to the earlier ephemerides E3. This comes as a surprise as E5 was constructed by including a large number of satellite pair positions of mutual event series of 1973, 1979, 1985 and 1991, while E3 used only those of 1973 and 1979 (Lieske, private communication). We suggest that the reason for this discrepancy may be at least partly due to shift of the photo-center from the geometric-center on the satellites due to albedo variations on their surfaces. In a given apparition, the mutual event series involving a given satellite pair dominate in number and occur near the same orbital longitudes within ± 20 deg. All the events are therefore delayed or advanced depending on the mean value of the shift in the photo-centre. The associated values of (O-C) in longitude may enter as dynamical errors in the newly constructed ephemerides. Hence, in order to fully exploit the potential of the mutual event data set, the astrometric information from the light curves should be extracted by taking into account the albedo variations on the satellites to remove the photometric effects.

(R. Vasundhara)

Solar-terrestrial physics and geophysics

Solar terrestrial physics

Solar wind-magnetosphere-ionosphere coupling

A halo coronal mass ejection (CME) left the Sun around 1054 UT on July 14, 2000 and the CME-driven shock wave impacted the Earth's magnetosphere at 1437 UT on July 15, 2000 and produced a severe magnetic storm the largest such event in nearly a decade. This magnetic storm which has come to be popularly known as the *Bastille day* storm is an event of much current research from the view point of the multi-faceted Sun-Earth connections. The equatorial ionosphere in the Indian sector is found to respond dramatically to the *Bastille day* storm. IPS42 digital ionosonde measurements at Kodaikanal, Waltair and Trivandrum showed an anomalous and extremely rapid decrease in F layer height (maximum value close to dip equator, 215 km/hr) simultaneously at all the stations around local midnight during the storm main phase on July 15, 2000. Careful analysis of the geomagnetic and ionospheric data showed that the abnormal midnight descent of equatorial F region indicative of a short-lived westward electric field disturbance (peak amplitude ≈ 4.6 mV/m) is due to prompt penetration of convection electric fields associated with impulsive injections of the magnetospheric ring current. This is the first time evidence for the occurrence of such a large amplitude westward penetration electric field around local midnight, in an environment under the influence of eastward electric fields due to the 'disturbance dynamo' mechanism. The case study highlights the profound manner in which the equatorial F region plasma dynamics can get modified during the main phase of severe magnetic storms. This result has important practical implications because of the role of plasma dynamics in the generation of F region plasma density irregularities in the night sector that are detrimental to telecommunications.

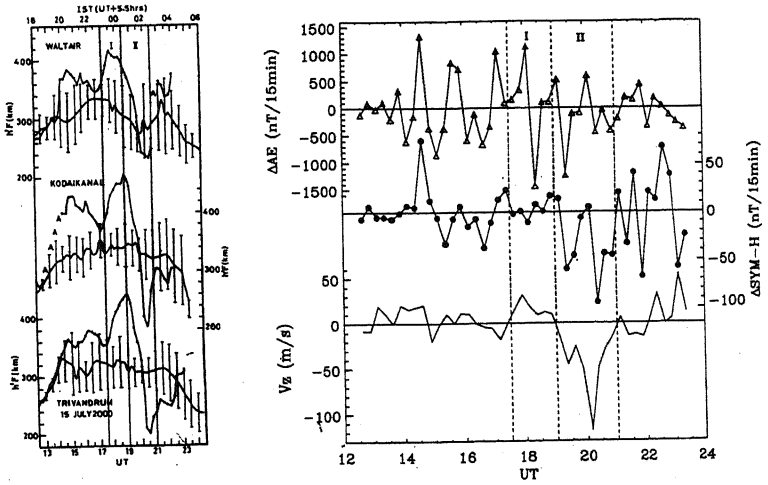


Figure 7 : (Left) Anomalous and rapid decrease in ionospheric F region height (h'F) around local midnight (19 UT) over equatorial locations in the Indian sector during the main phase of the 'Bastille day' magnetic storm of July 15, 2000.

(Right) Vertical drift (V_z) of ionospheric F region over Trivandrum (derived from h'F data and corrected for chemical loss effects) on July 15, 2000 showing the association of the dramatic downward drift disturbance (westward electric field) around local midnight (19 UT) with impulsive intensifications of the magnetospheric ring current (decreases in ΔSYM-H - see interval marked II)

(J. H. Sastri, Niranjan*, Subbarao*)

Ionospheric oscillations

Global scale oscillations in the earth's magnetosphere-ionosphere system were found to follow the impulsive increase in the solar wind dynamic pressure from 1.5 nPa to 4.0 nPa over the interval 1002-1008 UT on November 9, 1997. This evidence was obtained from simultaneous measurements with

multiple spacecraft and groundbased instruments. The magnetospheric compression affected by the solar wind pressure pulse generated drift echoes in the outer radiation zone, with the strongest echoes from electrons in the energy range 100-200 keV. Ground based magnetometers registered periodic enhancements of ionospheric currents with a period of 60-70 min, the same as of the drift echoes. This periodicity was, however, not shared either by the solar wind dynamic pressure or the interplanetary magnetic field (IMF), implying thereby that the solar wind does not play any role once the oscillations are excited. The period of the drift echoes is determined by the energy of the drifting electrons and the asymmeteric distribution of the drifting electrons may generate disturbance in electric fields which may then map and penetrate through the plasmasphere resulting in surface magnetic field oscillations at middle, low and equatorial latitudes. The study thus suggests a new source of ionospheric oscillations in association with magnetospheric drift echoes generated by solar wind pressure pulses.

(Chao-Song Huang*, J. C. Foster*, G. D. Reeves*, J. Watermann* J. H. Sastri, K. Yumoto*, P. Song*)

The SSCs

The geomagnetic storm sudden commencement (SSC) of July 8, 1991 was characterized by a reducion (enhancement) of X/H-component at midlatitudes in the noon (midnight) sector in the 1-hr period after its start at 1636 UT. This distinctive feature was seen even after accounting for the effects of Chapman-Ferraro currents in the magnetopause. The HF Doppler radar measurements of F region vertical plasma drift over Kodaikanal revealed that, over the same 1-hr period after the SSC on July 8, 1991, an eastward electric field disturbance grew up and decayed near the premidnight magnetic equator . The eastward electric field is interpreted as the signature of the penetration of the dawn-to-dusk electric field associated with an enhancement of region-1 field-aligned currents (FACs) driven by the solar wind. The reduction in groundlevel X/H-component at midlatitudes in the noon sector finds a logical explanation in terms of the magnetic effects of FACs that carry the large scale electric fields from the magnetosphere to the polar ionosphere and also of the DP2 type ionospheric currents excited by the large scale electric fields.

(J. H. Sastri)

Developmental work

Preparations are nearing completion for the installation of the DMI digital fluxgate magnetometer as the replacement for the aged La Cour Variometer which has been in round-the-clock operation in Kodaikanal Observatory since 1949. The DMI fluxgate system is on par with IAGA standards and provides geomagnetic data with high sensitivity and time resolution to address several problems in STP that was not possible before.

(J. H. Sastri, J. V. S. V. Rao* and V. Ponnurangam*)

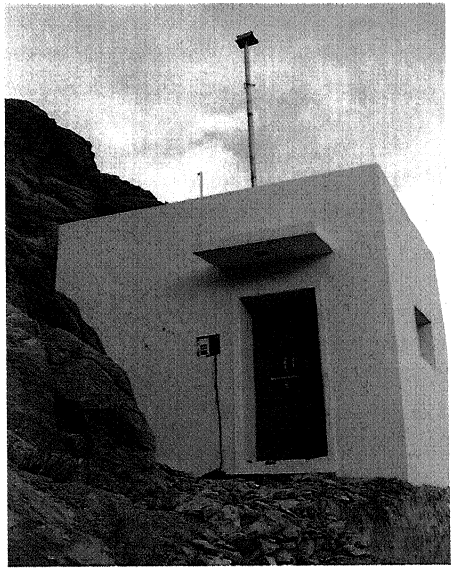
Geophysics

Shear velocity structure and kinematics of the Indian Plate

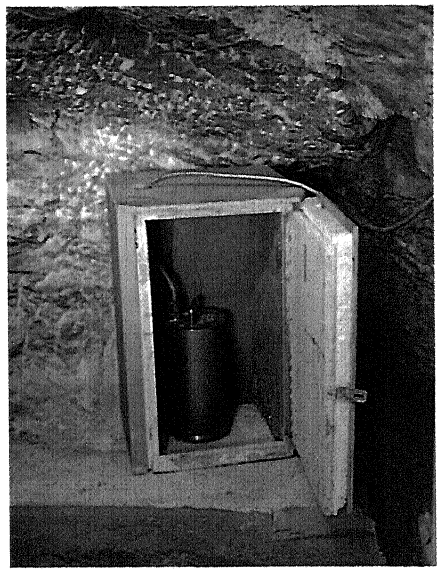
Structure : During the year a continuous recording Broadband Seismograph was installed in a specially designed vault (see the adjoining plates) hewn in the rock of a hill adjoining Mt. Saraswati at Hanle. The seismic data collected so far is currently being analyzed to invert for the underlying shear velocity structure in the area. Meanwhile, additional new data generated at Kodaikanal by seismic waves emanating from distant earthquakes which emerge almost vertically beneath the seismograph station and thereby sample the deep structure directly underneath, helped further refine the structure estimated earlier, and showed a strong anisotropy with the fast velocity direction directed E-W. This result is in marked contrast to that found in the crust beneath Bangalore which shows a weak anisotropy with the fast axis at N20*E in consonance with the plate velocity. Implications of these results could be profound and are being studied in conjunction with recent work on the petrology of the terrain.

Kinematics : Velocities at 10 sites in Ladakh derived from data generated over 1997-2002 show that the relative velocity of all these sites with respect to Leh is close to zero affirming that this trans - Himalayan region sandwiched between the Indo-Eurasian convergence zone does not suffer any internal deformation and moves southward almost aseismically over the Indian plate. The arcnormal velocity of Leh relative to Delhi at 14 ± 3 mm/yr thus represents mostly the elastic convergence within the Himalayan belt between Ladakh and the Indian plains. Furthermore, the extension rate between Leh and Lhasa at 14 ± mm/yr attests to the fluid like spreading of Tibet, and disproves the widely accepted hypothesis that the Karakoram fault, one of the most dramatically marked fracture zone on earth, does not play a major role in accomodating the Indo-Eurasian convergence. More detailed work to further refine the strain gradient field across the entire Himalayan belt and further north is in progress.

(V.K. Gaur)



Broad band Seismograph Station at Hanle



Inside picture of the broad band Seismograph with a thermally insulated enclosure.

Stars and stellar systems

Studies of young stellar objects

This is an ongoing project aimed at understanding how stars form and young stellar objects evolve. Stars are born in the cores of interstellar molecular clouds. In the early pre-main sequence phase they are still surrounded by the parent cloud envelope. The young stellar objects (YSOs) generally have circumstellar disks that drive bipolar jets and outflows and also cause polarization of star light by scattering. YSOs in several star forming regions, and also YSO candidates at higher galactic latitudes, are being studied by emission-line imaging, spectroscopy and polarimetry. So far we have observed about 50 objects. Some new YSO candidates have been found. Optical measurements are being supplemented by observations in the infrared. It is found that the polarization position angles are often aligned with the outflow directions. A number of YSOs have undergone large photometric and spectral variabilities. There is evidence for effects of the environment on the evolution of circumstellar disks around the YSOs. Detailed analysis is in progress.

(H. C. Bhatt, P. Manoj, Maheswar Gopinathan)

Non-emission line young stars of intermediate mass

Optical spectroscopy of several intermediate mass candidate young stellar objects, that have often been classified as Herbig Ae/Be stars, has been carried out. Typical Herbig Ae/Be emission features are not present in the spectra of these stars. Three of them, HD 36917, HD 36982 and HD 37062 are members of the young Orion Nebula Cluster (ONC). This association constrains their ages to be $\lesssim 1$ Myr. The lack of appreciable near infrared excess in them suggests the absence of hot dust close to the central star. But they do possess significant amounts of cold and extended dust component as revealed by the large excess emission observed at far infrared wavelengths. Fractional infrared luminosity (L_{ir} / L_{star}) and the dust masses computed from IRAS fluxes are systematically lower than that found for Herbig Ae/Be stars but higher than those for Vega-like stars. These stars may then represent the youngest examples of Vega phenomenon known so far. In contrast, one star in our sample, HD 58647, is more likely to be a classical Be star as evident from the low L_{ir} / L_{star}, scarcity of circumstellar dust, low polarization, presence of H_{α} emission and near infrared excess and far infrared spectral energy distribution consistent with free-free emission similar to other well known classical Be stars.

(P. Manoj, Maheswar Gopinathan, H. C. Bhatt)

High-resolution spectroscopy of QY Sge: an obscured RV Tauri variable

The first high-resolution optical spectra of QY Sge are presented and discussed. Menzies and Whitelock, on the basis of photometry and low-resolution spectra, suggested that this G OI supergiant was obscured by dust and seen only by scattered light from a circumstellar reflection nebula. The new spectra confirm and extend this picture. Photospheric lines are usually broad indicating scattering of photons from dust in the stellar wind. The presence of very broad, Na D emission lines is confirmed. Sharp emission lines from low levels of abundant neutral metal atoms are reported for the first time. An abundance analysis of photospheric lines shows that the stellar atmosphere is of approximately solar composition but with highly condensable (e.g. Sc and Ti) elements depleted by factors of 5 -10.

(N. Kameswara Rao, Aruna Goswami and *David L. Lambert)

Lithium and rotation in F and G dwarfs and subgiants

In collaboration with M. Parthasarathy and A.K. Pati, I have completed a study of Li abundance in a sample of 84 F and early G dwarfs and subgiants. These stars have been chosen on the basis that they are slightly evolved off

the main sequence, thus ensuring they have completed whatever lithium depletion occurs on the main sequence. A large scatter in Li abundance is found in these stars indicating that the Li depletion is not dependent only upon the spectral type and the age. Standard stellar model calculations are unable to explain Li depletion itself in stars with thin convective envelopes and fail to predict this scatter too. Our observations suggest that Li depletion/ dilution on the main sequence is aided by non-standard processes. The present study was undertaken to examine, in particular, the effects of rotation on the depletion of Li. No one-to-one correlation is found between the Li abundance and the present *v sini*. Instead the observed abundances seem to be dictated by the rotational history of the star. Li depletion might be occurring as a result of mixing induced by differential rotation when a rapidly rotating star spins down on the main sequence and the range in Li abundances could be a direct consequence of the initial range in rotational velocities that the stars had when they arrived on the main sequence.

(S.G.V. Mallik)

Li and rotation in F, G and K giants

Cool giants are observed to have severe depletions in Li, far in excess of the standard stellar model predictions at temperatures cooler than 5000-5500K. The above study has been extended to a large sample of giants to explore whether a large scatter similar to what is observed in subgiants, exists for giants hotter than 5000-5500K and if this suggests any link with rotation. High resolution CCD spectra have been obtained of 135 F, G and K giants in the region of the Li I line at 6707.8 Å using the coude echelle spectrograph at the 102 cm telescope at VBO in Kavalur and the Li abundances have been determined. Similar patterns of behaviour are observed as in subgiants. There is a dramatic drop in rotational velocities for stars later than G0 III where it tapers off to low values ranging between 2 and 6 km sec^{-1}. There is a concentration of Li depleted stars at small *v sini* and a sparseness of these at large *v sini*. Only stars of high Li content seem to exist at large *v* sini. At small *v sini* a large spread in log N(Li) exists which rules out the possibility of a one-to-one correlation between Li abundance and the present *v sini* but might imply a link with the rotational velocity that these stars are endowed with at birth. The Li evolution of the combined sample of dwarfs, subgiants and giants totalling to 219 has been studied as a function of age, mass and rotation against the backdrop of the evolutionary tracks plotted on the HR diagram.

(S.G.V. Mallik)

Spectroscopic survey of field stars: A search for metal-poor stars

We have undertaken a spectroscopic survey of field stars to find metal-poor objects among them. Though the main objective of the survey is to find new metal-poor stars, stellar parameterization is carried out for all the sample stars so that the other categories of interesting objects like composite stars, weak or strong CN, CH stars etc. can also be identified.

Observations are carried out using OMR spectrograph attached to VBT, Kavalur. The sample of candidate stars are chosen from prismatic survey of Beers et al. 1992 Z (AJ, **103**, 1987) covering a large part of the Galaxy. At the first phase of this project, the analysis is completed for a set of 19 relatively hot stars (T_{eff} in 6000 to 8000 K range). The metallicities of the program stars are derived by synthesizing the spectrum in the wavelength range 4900 to 5400 Å for different metallicities and matching them with the observed spectra. This spectral region contains strong feature of FeI at 5269 Å and one moderately strong Fe I blend at 5228 Å. These features were generally relied upon for Fe/ H determination. More than half of the candidate stars were found to show [Fe/H] in – 0.7 to – 1.2 range. Two most metal-poor stars have [Fe/H] values of – 1.3 and – 1.8. It appears that metal-poor candidates suggested by Beers et al. from their prismatic survey have a very significant fraction of metal-poor stars. The significantly metal-poor stars found so far would be studied in detail using high resolution spectra to understand nucleosynthesis processes that might have occurred in early Galaxy.

(Sunetra Giridhar and Aruna Goswami)

A revised calibration of M_V – W(OI 7774) relation using Hipparcos data

A new calibration of the M_V – W(OI 7774) relationship has been calculated using more accurate estimates of parallaxes and proper-motions available from Hipparcos data that have led to better estimates of reddening and distances to a sample of 24 calibrator stars of A-G spectral types. We further tried to minimize the calibration errors by attempting two independent calibrations , one using the bluemost component at λ 7771.954 (W71) and other for the full blend by summing contributions of three lines comprising the triplet (W74). These two calibrations predict absolute magnitude with accuracies of ± 0.42 and 0.43 mag. respectively for a sample covering a large range of M_V, from – 9.5 to + 0.35 mag. The behaviour of the OI7774 feature in classical Cepheid SS Sct has been studied over its pulsation cycle. A phase-dependent scale factor has been calculated such that the observed strengths of OI feature for a given Cepheid at a random phase could be used to estimate its absolute magnitude.

We use our derived calibration to estimate M_V for a set of evolved objects to be able to locate their positions in the H-R diagram.

(A. Arellano Ferro*, S. Giridhar, E. Rojo Arellano*)

Large scale structures in OB stellar winds

A program of observations of OB stars with a view to studying stellar winds associated with them was initiated. Many OB stars show evidence of co-rotating extended wind structures. Time resolved spectroscopic monitoring of such stars, especially with the IUE, have shown instances of cyclic variability patterns of lines formed in the winds. These are believed to arise from rotational modulation of co-rotating, azimuthally extended wind streams. Fast streams emerging from spots on the photospheric surface of the star are curved by stellar rotation. The development of such wind structures is possibly related to variations in the physical conditions in the photosphere i.e., pulsational and magnetic activity in early type stars. Time resolved spectroscopic monitoring remains the only means of establishing the incidence of these wind structures. Previous effort in such studies have lacked in the number of stars monitored as well as poor temporal sampling.

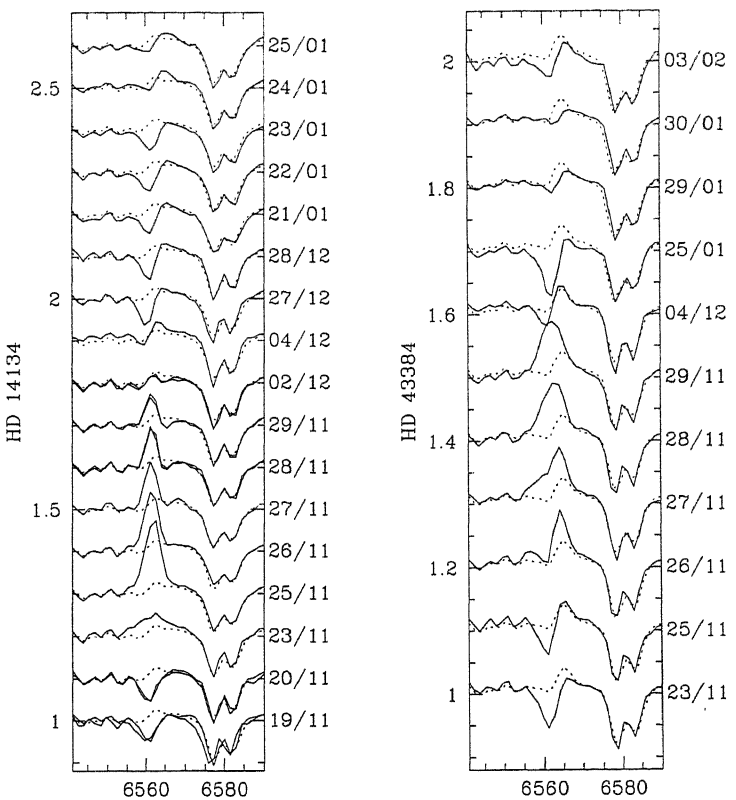


Figure 8 : A plot of the variation in the H_α line shape for two of the stars from the OB star sample. The dates on the right-hand side axis refer to Nov 2001 through to February 2002. The dotted curves are preliminary model fits.

We have obtained time resolved spectra for a sample of a dozen, apparently single OB stars. Mainly supergiant stars have been selected to ensure the

presence of strong H_α emission. Spectroscopic monitoring with the UAGS spectrograph at the 1 metre telescope at VBO has been carried out over ten to twelve contiguous nights in November and December 2001 and over runs of a few nights during January and March 2002. Fig. 8 shows the dramatic variations in the H_α line seen for two of the stars. These preliminary results have been encouraging and further observations are planned in the coming months. The detailed reduction of the data in progress.

(A.K. Pati, T. Morel*, S. Marchenko*, K. Kuppuswamy)

Post-AGB stars

Using radiative transfer models of dust shells, parameters like mass-loss, shell inner radius, dust temperature, outflow velocity etc., have been derived for two Post-AGB stars HD 179821 and HD 56126. Models have also been presented for HD 101584 and HD 100764.

(R. Surendiranath)

Photometry and low resolution spectroscopy of hot post-AGB candidates

We have obtained Johnson U, B, V and Cousins R, I photometry and low resolution spectra of a small sample of hot post-AGB candidates. Using the present data in combination with JHK data from 2MASS, infrared data from the MSX catalog and the IRAS fluxes, we have studied the spectral energy distribution (SED) of these stars. We have estimated the effective temperature of the stars, the dust temperatures, distance to the stars, height above the galactic plane, the dynamical ages of the circumstellar shells, mass-loss rates and the circumstellar dust mass. These candidates have also been imaged through a narrow band H alpha filter, to search for nebulosity around the central stars. Our H alpha images revealed the bipolar morphology of the low excitation PN IRAS 17385-0841 with an angular extent of 2.8 arcsec. The bipolar lobes of IRAS 17423-1755 in H alpha were found to have an angular extent of 3.5 arcsec (south-east lobe) and 2.2 arcsec (north-west lobe). The dust envelope characteristics, low resolution spectrum and IRAS colors suggest that IRAS 18313-1738 is a proto-planetary nebula (PPN) with a hot post-AGB central star similar to HD 51585. The SED of IRAS 17423-1755, IRAS 18313-1738 and IRAS 19127+1717 show a hot dust component (in addition to the cold dust) which may be due to recent and ongoing mass-loss.

(G. Gauba, M. Parthasarathy, Brijesh Kumar*, R.K.S. Yadav*, and Ram Sagar)

UV(IUE) study of IRAS selected hot post-AGB stars

We have analysed the UV(IUE) spectra (1150 Å to 3200 Å) of 18 hot post-AGB stars selected on the basis of their IRAS colors. We studied the interstellar and circumstellar reddening of these stars using the 2200 Å feature. From the analysis of spectral energy distributions we have determined the temperatures, gravities and metallicities of these stars. We have also searched for spectral variability in the UV among the sample of stars. The stars have been placed on the log g-T_{eff} plane to better understand their evolutionary status. Some of these stars have violet shifted CIV 1550 Å resonance doublet indicating stellar wind and post-AGB mass loss.

(G. Gauba and M. Parthasarathy)

IUE and ISO observations of the bipolar proto-planetary nebula Hen 401 (IRAS 10178-5958)

We present ultraviolet (IUE) and infrared (ISO) observations of the bipolar proto-planetary nebula Hen 401 which, combined with previously available optical and near infrared data, are used to reconstruct the overall spectral energy distribution from 1150 Å to 100μ. The ISO spectrum is dominated by strong PAH emission superimposed on a very cold continuum which is interpreted as thermal emission originating in the C-rich cool dust (~ 106 K) present in the circumstellar envelope, the remnant of the previous AGB phase. In addition, a second, hotter component detected in the near infrared is attributed to thermal emission from hot dust (~ 640 K), suggesting that mass loss and dust grain

formation is still on going during the current post-AGB phase. The ultraviolet (IUE) spectrum shows a stellar continuum in the wavelength interval 2400 Å to 3200 Å which corresponds to a moderately reddened B8-type central star. Unexpectedly, the UV flux in the wavelength interval 1150 Å to 1900 Å is very weak or absent with no evidence of a hotter binary companion which could explain the detection of the nebular emission lines observed in the available ground-based optical spectra of Hen 401. HST WFPC2 high resolution images also show no indication of a hot companion to the B8-type central star observed both in the optical and in the UV. The evolutionary implications of a possible single nature for the central star of Hen 401 are discussed.

(M. Parthasarathy, P. Garcia-Lario*, G. Gauba, D. de Martino*, Y. Nakada*, T. Fujii*, S. R. Pottasch*, and L. San Fernandez de Cordoba*)

Low resolution spectroscopy of ISOGAL sources: Search for early-type stars with infrared excess

An analysis of low resolution spectra and infrared data of 29 ISOGAL-DENIS sources with mid-IR excess is presented. Eight ISOGAL sources from our sample with 7-15 μ excesses are found to be B and A-type stars, some of them with emission lines. Two ISOGAL sources, J175614.4-240831 (B3-4IIIe) and J173845.3-312403 (B7IIIe), show a bump between 5000 and 6000 Å which may be attributed to extended red emission (ERE). Some of the B, A and F-type giants with a large infrared excess might be in the post-AGB phase.

For about 50% of the sources in this preliminary study, a nearby second (or even multiple) component was found. Such sources, in particular two B-stars, are not discussed when the probability of the optical spectrum being associated with the ISOGAL source is low. These results confirm that the DENIS-ISOGAL I – J/K–[15] diagram is the most suitable diagram to distinguish between early (AB) and late spectral types (KM). It provides the most useful tool to systematically search for nearby early-type stars with an infrared excess among the background of distant AGB stars in ISOGAL fields of the Galactic disk.

(M. Schultheis*, M. Parthasarathy, A. Omont*, M. Cohen*, S. Ganesh*, F. Sevre*, and G. Simon*)

BVRIJHK photometry of post-AGB candidates

BVRIJHK photometric observations are presented for 27 post-AGB candiates. Almost all objects show a double peaked SED curve in the optical to far-infrared wavelengths. Seventeen objects were classified as post-AGB stars on the basis of their spectral types, location in the IRAS color-color diagram and SED. The physical parameters of the observed post-AGB stars, the inner radius of the detached shell, the mass of the shell and the distance were derived using the simple dust shell model. We compared our observational sequence of post-AGB objects to the theoretical evolutionary sequence (Schönberner 1983; Blöcker 1995) in the stellar temperatures versus age diagram. We found that two post-AGB stars, IRAS 05040+4820 and 08187-1905, have low stellar temperature with a large dynamical age of the dust shell. They appear to provide the first observational evidence that some low-mass stars bypass the planetary nebulae stage because of their slow increase in stellar temperature.

(T. Fujii*, Y. Nakada*, and M. Parthasarathy)

Detection of zinc in the very metal-poor post-AGB star HR 4049

We report the detection of two Zn I lines at 4722.15 Å and 4810.53 Å in the high-quality spectrum of the very metal-poor post-AGB star HR 4049, which was obtained with the high dispersion spectrograph attached to the Subaru Telescope. The strengths of these lines indicate an appreciable underabundance of Zn by ~ – 1.3 dex relative to the Sun. The fact that this volatile element, similar to the others belonging to the same group (e.g., C, N, O, S), does not conform to the extreme depletion (> 4 dex) of refractory metals (e.g. Fe), strongly suggests that the grain formation has something to do with the origin of the chemical peculiarity. This (not extremely but markedly) subsolar value of [Zn/H] is quantitatively discussed in connection with those of other volatile species, especially with respect to S. We also detected a new Fe II line at 5159.03 Å along with the already known Fe

II 4923.93 Å line; based on these two lines the Fe abundance of HR 4049 was determined to be ~ 2.8 ([Fe/H] ~ – 4.7).

(Y. Takeda*, M. Parthasarathy, W. Aoki*, Y. Ita*, Y. Nakada*, H. Izumiura*, K. Noguchi*, M. Takada-Hidai*, B. Sato*, A. Tajitsu*, S. Honda*, S. Kawanomoto*, H. Ando* and H. Karoji*)

The parent population of novae in the Large Magellanic Cloud

A study of the local, projected stellar population around novae in the Large Magellanic Cloud has been made in order to identify and understand the parent population of novae. The star formation history of the local environment around novae is studied based on photometric data of stars and star clusters in the nova neighbourhood, available in the OGLE II survey and star cluster catalogues. The age of the stellar population within a few arcmin around novae regions are estimated using isochrone fits to the V vs (V–I) colour-magnitude diagrams. The fraction of stars in various evolutionary states are compared using luminosity functions of the main-sequence stars and the red giant stars.

The age, density and luminosity function of the stellar population are estimated around 15 novae. The upper limit of the age of the intermediate stellar population is found to be 4 Gyr in all the regions, excepting the region around the slow nova LMC 1948. Star formation in these regions is found to have started between 4 – 2.0 Gyr, with a majority of the regions starting star formation at 3.2 Gyr. This star formation event lasted until 1.6 – 0.8 Gyr.

The star formation history of the underlying population of both the fast and moderately fast novae indicate their parent population to be similar and likely to be in the age range 3.2–1.0 Gyr. This is in good agreement with the theoretical age estimates for Galactic cataclysmic variables.

The region around the slow nova shows a stellar population in the age range 1–10 Gyr, with a good fraction older than 4 Gyr. This indicates that the progenitor might belong to an older population, consistent with the idea that the progenitors of slow novae belong to older population.

It is the first attempt where the parent population of novae has been identified by studing the underlying stellar population. Previous studies to identify the parent population were based on the distribution of novae and statistical methods.

(A. Subramanian and G.C. Anupama)

V445 Pup

The analyses of the spectra obtained during the nova-like outburst of V445 Pup indicate this nova event to be a peculiar one. Quite unlike other novae, this object is found to be hydrogen deficient. The spectra do not show any hydrogen lines, while the lines due to Fe II and other elements present in the spectra are very similar to those found in novae. A detailed analysis of the data is in progress.

(U.S. Kamath and G.C. Anupama)

IM Nor

The recent nova outburst of IM Nor in January 2002 places it among the class of recurrent novae, with the previous recorded outburst being in 1920. The spectral development of the 2002 outburst is being monitored from VBO, since February 2002. Initial data indicate this object to be a moderately fast slow nova, similar to the recurrent nova T Pyx. The spectral development similar to the 'hybrid' novae, where the nova changes from an initial 'Fe II' type to the 'He/N' type. Observations of this nova are being continued.

(G.C. Anupama)

Supernovae

SN 2001X : The spectroscopic data of SN2001X were obtained from VBO and the photometric data were obtained from IAO. The analyses of the data indicate the supernova to be of Type II-P, and that the observations were made during the plateau phase. The evolution of the photospheric temperature and the velocity are similar to those of other Type II-P supernovae in the plateau phase. Detailed analysis of the data is in progress.

(G.C. Anupama and D.K. Sahu)

Symbiotic stars

The project related to long-term monitoring of symbiotic stars in the optical, initiated in 1999 is continuing. Spectra of 8 systems have been obtained from VBO. The optical spectra will be combined with data in other wavelength regions to study the various problems posed by the activity of these binaries, such as the multiple outbursts, variability in the emission lines and luminosity of the hot component, and information about mass transfer and accretion.

(G.C. Anupama and J. Mikolajewska*)

Planetary nebulae

Photoionization modeling has been done to deconstruct the planetary nebula Vo 1 and derive its physico-chemical characteristics.

(R. Surendiranath)

Rapid follow-up observations of GRB afterglows

The afterglow of GRB 011211 was observed using the 2.34 m as well as 1.02 m telescopes at VBO Kavalur during 12–14 Dec, 2001. The afterglow was detected in our images and the results of quick-analysis were reported in GCN Circular No.1202. The detailed analysis has been completed and the data set is fitted by two existing models for the GRB afterglows. Following the Fire-Ball (FB) model we fit a smoothly broken power-law of the form

$$F_\nu(t) = \frac{2F_{\nu,0}}{[(t/t_b)^{\alpha_1 s} + (t/t_b)^{\alpha_2 s}]^{1/s}}$$

and obtain the following parameters: t_b = 1.22 ± 0.197 *days* α_1 = –0.723 ± 0.07 ; α_2 = – 1.593 ± 0.146 (temporal slopes before and after the break), for the smoothness parameter s = 10. Interestingly, we get a similar fit using the Cannon-Ball (CB) model (Dado et al. 2001). The χ^2 (d.o.f = 19) is 2.42 and 2.27 for FB and CB models respectively.

We are co-ordinating with the authors from State Observatory, Naini Tal as well as Very Large Telescope (VLT) to make a combined paper

(R.Cowsik and S.G. Bhargavi)

Optical photometry of the GRB 010222 afterglow

The optical afterglow of GRB 010222 was observed using the recently installed 2-m telescope at the Indian Astronomical Observatory Hanle and the telescopes at the Vainu Bappu Observatory, Kavalur, beginning ~ 0.6 day after the detection of the event. The results based on these photometric observations combined with others reported in the literature are presented in this paper. The *R* band light curve shows an initial decline of intensities proportional to $t^{-0.608}$ which steepens, after 10.6 hours, to $t^{-1.24}$. Following the model of collimated outflow, the early break in the light curve implies a very narrow beam angle (~ 3°). The two decay rates are consistent with the standard jet model in a uniform density ambient medium, but require a hard spectrum of electron power density with α ~ 1.5. The early spectral energy distribution derived using published fluxes in different bands and our *R* band light curve suggests that the ambient density is very low : n ~ 1 cm^{-3}. GRB 010222 is thus an example of a highly collimated outflow with a hard spectrum of electron energy distribution in a low density environment.

(R. Cowsik, T.P. Prabhu, G.C. Anupama, B.C. Bhatt, D.K. Sahu, S. Ambika, Padmakar, S.G. Bhargavi)

Star formation versus cluster formation around six regions in the Large Magellanic Cloud

The stellar population and star clusters around six regions in the Large Magellanic Cloud (LMC) are studied to understand the correlation between star formation and cluster formation episodes. We used the stellar data base of the OGLE II LMC survey and the star cluster catalogues. The analysis of the colour-magnitude diagrams (CMDs) were used to estimate the ages of the stellar population. It is found that most of the regions have undergone three major star formation episodes. The star formation which began about 4 Gyr ago, continued upto around 1 Gyr, or continued further. The other two events have taken place around 300 Myr, and 100 Myr. A few star clusters were formed during the first of the three star formation events in 5 regions. In all the six regions, a good correlation is seen between the star formation and the cluster formation events which occurred at 300 Myr and 100 Myr. The cluster formation events and the fraction of star clusters formed were found to be very similar for two regions located to the south-east of the Bar, suggesting similar cluster formation triggers at almost similar instances. The two recent star formation events seem to correlate with the interactions of LMC with Small Magellanic Cloud (SMC) and Galaxy. Hence it is quite likely that the young populous star clusters in the LMC are formed as a result of the star formation events started due to galaxy-galaxy interactions and the further propagation of such star formation.

(Annapurni Subramaniam)

NGC 1245: a high galactic latitude, old open cluster

NGC 1245 is an old open cluster with age around 1 Gyr and located away from the plane of the Galaxy. This cluster is located 444 pc away from the plane of the Galaxy and hence it is kinematically interesting. This cluster was observed from VBT and the reductions of the data were done to obtain the photometric magnitudes and colour. The analysis of the Colour - Magnitude Diagram (CMD) shows that the main-sequence is quite wide. Further analysis showed that there is substantial differential reddening in the direction of this cluster. The maximum variation in reddening was found to be 0.20 mag and the mean reddening was estimated as 0.29 mag. Thus the cluster is estimated to be located about 3000 pc away. The CMD, which is corrected for the differential reddening, is fitted with isochrones to estimate age, and it is found to be 800 Myr old. The radial density profile of the cluster is estimated after correcting for the data incompleteness and field star contamination. The profile shows that the central region of this cluster is deficient of stars. The cluster has a radius of 3.5 arcmin, and the central 1 arcmin is found to have a dip in the profile, indicating that there is less number of stars than expected. This cluster seems to have lost stars in the central region. As this cluster is located towards the Perseus spiral arm, possible reasons for stripping of stars are interaction with molecular clouds or star clusters.

(Annapurni Subramaniam)

Study of the GRB remnants from nearby galaxies

We have initiated an observational program since Jan 2002 to search for the GRB remnants using the Perna et al. (2000) method. The goal is to look for peculiar line ratios viz. [OIII]λ 5007/H_β, He IIλ 4686/H_β and thereby identify the cooling remnant of the GRB in the nearby galaxies observed with 2.34 m VBT at Kavalur. We propose to use the facilities at IAO, Hanle in future.

(S. G. Bhargavi, R. Cowsik, R. Perna*, J. Rhoads*)

H_α and broad-band imaging of dwarf galaxies

The H_α and broad-band imaging observations have been initiated since Jan 2002 using the 2.34 m VBT. The optical data will suppliment the on-going radio (21-cm) observations using the GMRT, Pune. The objective of the program is to study the star-formation and distribution of dark matter in this class of galaxies dominating the local universe. A few dwarf galaxies have been observed with VBT during the Jan-Mar trimester and the data analysis is underway. We plan to use the facilities at IAO, Hanle in future.

(J. Chengalur*, S. G. Bhargavi, S. Sethi*, S. Bharadwaj*)

Effect of poor cluster environment of galaxies

The thesis work of Mangala Sharma (supervised by T.P. Prabhu) explores the effects of the poor cluster environment on galaxies. The motivation for the work stems from the observed variations in galaxy properties and scaling relations across the vast spectrum of galaxy neighborhoods. The data are deep, multiband (B, V, R and I) optical images of 4 poor clusters of galaxies at intermediate redshifts acquired using CCD detectors at the 2.3 m Vainu Bappu Telescope.

We study several statistical properties of the galaxies in the poor clusters such as the luminosity functions, the color-magnitude diagrams and the blue fractions, and the spatial segregation in terms of color or luminosity.

The galaxy luminosity functions are not dissimilar in the clusters, and in the various filters. When fit by a Schechter function, the luminosity distributions exhibit a flat slope; however, these are steeper than the corresponding behavior of field galaxies. But the restricted luminosity ranges we probe do not allow a comparison of the dwarf galaxy populations between the poor and rich clusters.

The poor cluster environment affects the colors of the brightest early-type galaxies in a similar fashion as its rich counterpart, but hosts a larger fraction of galaxies which appear to be actively forming stars. The triggering and sustenance of star-formation may be due to the low velocity-dispersion expected for poor clusters which results in enhancing the galaxy encounter and merger rates.

The morphologies of the clusters indicate that they are mostly unrelaxed, but at different stages of dynamical evolution. The clusters also show some mild evidence for luminosity segregation: the brighter galaxies are more clustered, implying that these at least have undergone dynamical relaxation.

We have also studied several aspects of the brightest cluster members. While the main body of the galaxies is elliptical, there are deviations from a 'pure' de Vaucouleurs' law, implying the superposition of disk-like structures on the elliptical body. Further, the cD galaxy that dominates one of the poor clusters is a rare, steep-spectrum radio source whose origin may be tied to the cooling flow in the cluster. The brightest cluster galaxies also have their major axes aligned with the cluster elongation and X-ray emission, implying their dynamical connection with the large-scale environment.

(Mangala Sharma and T.P. Prabhu)

Jets in Seyfert galaxies

Using our global VLBI observations of a sample of Seyfert galaxies that were an equal mix of face-on and end-on objects selected to be intrinsically similar in the framework of the Unified Scheme, we had found that the pc-scale compact radio components in the face-on and end-on Seyferts were similar, consistent with the predictions of the Unified Scheme. Further analysis of these data indicate that the compact features that we detect may not be arising from the nuclear regions in all cases. We have recently obtained new radio imaging data with the European VLBI network and MERLIN to examine this question in detail, and its implications for the physics of the jets in Seyferts.

(P. Shastri, D. Gabuzda*)

Radio galaxies and the Fanaroff-Riley dichotomy

The properties of the optical synchrotron-emitting nuclei of radio galaxies discovered by the Hubble Space Telescope have been investigated in the context of the relativistic beaming scenario. While the optical nuclei in the FRI-type galaxies appear to be the unbeamed counterparts of those in the BL Lac objects, those in the FRII-type galaxies appear consistent with being the unbeamed/ obscured counterparts of quasars. Orientation effects that are a combination of relativistic beaming, disc-projection effects and an obscuring torus appear to fit the current data.

(P. Kharb and P. Shastri)

Magnetic fields in the nuclei of BL Lac objects

The geometry of the ordered component of the magnetic field in the nuclei of BL Lacs has been known to be systematically different from that in quasars, in that while in the BL Lacs it tends to be oriented perpendicular to the local jet direction, in quasars it tends to be oriented parallel to it. While these BL Lacs were those selected via their radio emission and have their Spectral Energy Distributions peaking in the IR region, we have looked for such systematics in BL Lacs selected via their X-ray emission (which tend to peak in the soft X-ray region), using Very Long Baseline Polarimetry at radio wavelengths. We find that for these objects, the magnetic field tends to align with the jet direction in the majority of the cases.

(P. Kharb, D. Gabuzda*, and P. Shastri)

Magnetic fields in the nuclei of radio galaxies

The structure of the magnetic field in the nuclei of radio galaxies is being investigated on the pc-scale with Very Long Baseline Polarimetry at radio wavelengths, and global observations for a few galaxies have just been made. The goal is to understand the physics behind the correlation between jet-luminosity and jet-morphology, and also to simultaneously test predictions of the Unified Scheme for radio galaxies.

(P. Kharb, P. Shastri and D. Gabuzda*)

Hot gaseous outflows in Seyferts

We investigate whether orientation plays a dominant role in the observed hot gaseous outflows in Seyfert galaxies. We propose to do this by contrasting the properties of the O VI absorbers at different orientations within the framework of the Unified Scheme using observations with NASA's Far-Ultraviolet Spectroscopic Explorer telescope. The O VI emission line is present in all Seyferts, and is a unique characterizer of the kinematics of gas at $\sim 10^6$ K. We have obtained observing time to be scheduled in 2002 for this purpose.

(P. Shastri, J. Murthy and J. Hutchings*)

Active Galactic Nuclei

Variability studies of AGN were continued using CCD imaging photometry with the VBT. Some of the objects have been observed as part of larger multi-wavelength campaigns carried out with the Whole Earth Blazar Telescope (WEBT). In particular, the results of optical and radio variability studies of the BL Lac object AO 0235+16 with the WEBT (including VBT data) were published during this period.

(A.K. Pati, P. Shastri with the WEBT team*)

Diffuse UV radiation

Using Voyager data, we have placed stringent upper limits on the amount of OVI emission in the Galactic Halo. We have used MSX data to observe starlight from the bright stars in Orion scattered by the interstellar dust in the region and are doing the same in the Coalsack. With P. Chakravarty, I am using the Hipparcos data to model the diffuse radiation field over the entire sky. This will be crucial to understanding the results from the upcoming ASTROSAT mission. With P. Shalima, I am modeling dust emission from various regions including the Coalsack. Through this, we can understand the properties of the interstellar grains.

(Jayant Murthy)

Theoretical astrophysics and cosmology

Galaxies

Dynamics

The relaxation time of a stellar system is the characteristic time required for an individual orbit to lose memory of its initial constants of motion through two body encounters. The relaxation time of simulations will be much shorter than that of galaxies which is much longer than the age of the universe. The relaxation time increases with the number of particles in a stellar system. Any computation done for times exceeding this time could have been affected by the effects of two body relaxation. Numerical simulations have been performed to evaluate the relaxation time of a galaxy modelled as a polytropic system with index n in the range $0 \leq n \leq 5$ consisting of a large number of particles N ranging from N=1024 to N=102400. The computations are performed using the GRAPE system special purpose computer. The results show that for the n = 3 polytropic model, the relaxation time depends on the number of particles in a linear fashion. The relaxation time shows tendency to decrease as the central concentration of the stellar system increases. However the dependence of the relaxation time on central concentration does not seems to be too strong and it scales inversely as the square root of the density. The numerical estimates agree with the theoretical values and the agreement becomes remarkably good for larger number of particles (i.e., for $N \geq 64K$).

(P.M.S. Namboodiri)

Pulsars

Understanding the radio emission geometry of multi-component radio pulsars from retardation and aberration effects

We have conducted a detailed analysis of the emission geometry of a handful of radio pulsars that have prominent, multiple-component profiles at meter wavelengths. From careful determination of the total number of emission components and their locations in pulse longitude we find that all of these pulsars show clear evidence for retardation and aberration effects in the conal emission beams. Using this result, we obtain very good estimates of the height and transverse location in the magnetosphere, for each of the emitting cones in these pulsars. These results support our earlier conclusions for PSR B0329+54 in that we find successive outer cones (in cases of multi-cone pulsars) being emitted at higher altitudes in the magnetosphere. The range of inferred heights is from ~ 160 km to ~ 1150 km. The set of "active" field lines from which the conal emissions originate are located in the region ~ 0.2 to ~ 0.7 of the polar cap radius. We discuss the implications of our new findings on the understanding of the pulsar emission geometry and its impact on the emission mechanisms.

(Y. Gupta* and R. T. Gangadhara)

Influence of rotation on pulsar profiles

A relativistic model for pulsar radio emission has been developed by including the effect of rotation on coherent curvature radiation by bunches. The model predicts that the rotation changes the width of emission components: broadens the width of leading component and narrows the trailing component. In this regard, we estimated the component widths in the average pulse profiles of about 30 pulsars, and find that 23 of them have a broader leading component. We explain this difference in the component widths by using the nested cone emission geometry followed by aberration and retardation effects.

We find pulsar spin can strongly modify the pulsar polarization, and the inclination between the rotation and magnetic axes can introduce an asymmetry

in the circular polarization of the conal components. We analyze the single pulse polarization data of PSR B0329+54 at 606 MHz, and find that in its conal components, one sense of circular polarization dominates in the leading component while the other sense dominates in the trailing component, as shown in Fig. 9 by panel (d) by a solid line curve. Our simulation shows that changing

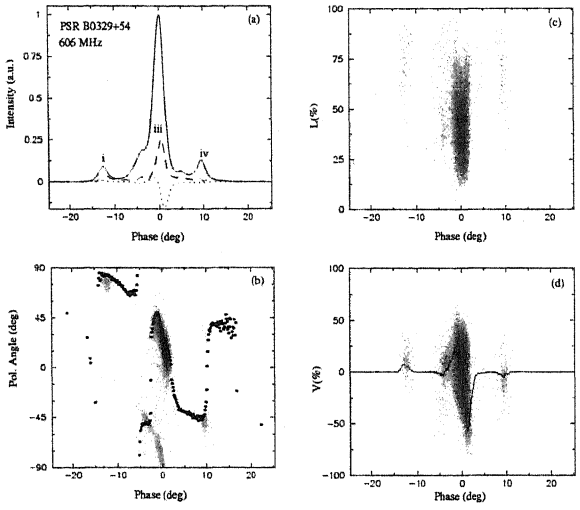


Figure 9 : (a) The average pulse profile of PSR B0329+54 with arbitrary intensity units (a.u), and (b) average polarization angle (ψ) (bullet symbols), and polarization angle gray-scale map obtained from individual pulses. The panels (c) and (d) represent the gray-scale maps of linear L (%) and circular V (%) polarizations. The shade is a number in the range 0 (white) and 1 (black) obtained by linear interpolation between the background and foreground levels. The average circular polarization curve (solid line) is superposed in the panel (d).

the sign of the impact parameter changes the sense of circular polarization as well as the swing of polarization angle.

(R. T. Gangadhara)

Radio pulsar emission altitudes

We present a new and a potentially powerful method for investigating emission altitudes of radio pulsar core and conal components by attributing them different altitudes. We provide a framework for a systematic understanding of resulting longitude offsets between them which are frequently observed. By investigating the contributions to these offsets due to aberration and the magnetic field line sweepback, we show that they are always dominated by aberration for all emission altitudes and inclination angles. This directly leads to the conclusion that the core emission does not necessarily come from the surface. Based on our results, the trends seen in the observational phase offsets imply that for a large number of pulsars the emission altitudes of core and conal components are close when compared to the light cylinder radius but not necessarily relative to the stellar radius. The altitude difference between core and conal components that we find are typically larger than the individual altitudes ascribed to them so far. Our results also allow very widely different but related core/cone altitudes. We find that data supports also this circumstance for some pulsars, which suggests a novel and natural explanation of the precursors in the Crab and similar pulsars. The pre- and post-cursor nature of these components arises because of large offsets caused by correspondingly large differences in the core and conal emission altitudes. We also show that the question of emission altitudes can not be divorced from considerations of the core/cone components' filling factors of the polar flux tube. We propose an empirical '1/3 rule' to concisely describe the observed core/cone morphologies. Combined with the core/cone phase offsets it allows a glimpse into the variation of these filling factors with altitude. Lastly, we outline how the full predictive potential of our results can be realised by combining them with a detailed analysis of the polarization and multifrequency observations.

(R.C. Kapoor and C.S. Shukre*)

Gravity on large and small scales

Recent astronomical observations show that on large scales the universe is expanding at an accelerating rate. This suggests presence of a dominant repulsive gravity component over cosmological scales. Again deviations from Newtonian gravity over submillimetre scale is motivated by recent ideas to unify gravity with other interactions. The possiblity of a submillimetric connection underlying both phenomena was explored. Experiments to detect

gravity deviations on small length scales used together with Casimir force measurements can put tight constraints on both a cosmological constant and extra dimensions.

(C.Sivaram)

Gravity effects on charged particle and neutron interferometers

Additional gravitational effects including that of torsion in the quantum interference of charged particles was investigated. Influence of axial torsion in the Shciff-Barnhill effect inside a metallic shell was estimated. Modification due to these effects of the Sagnac phase-shift of neutron beams have also been calcualted.

(C.Sivaram)

Schwarzschild black hole in the background of the Einstein universe

We have continued our research on black holes in non-flat backgrounds such as those generated by mass distributions surrounding the black hole or the universe itself. A prototype of this class is the Schwarzschild black hole in the background of the Einstein universe which is a special case of the representation of a black hole in a cosmological background given by Vaidya. We have completed investigations of some of the physical effects inherent to this spacetime. We have carried out a background - black hole decomposition of the spacetime in order to separate out the effects due to the background spacetime and the black hole. The physical effects we have studied include the classical tests - the gravitational redshift, perihelion precession and light bending - and circular geodesics. A detailed classification of geodesics, in general, was also carried out.

The background modifies all of the above phenomena significantly. We have therefore demonstrated the importance of taking into account the background influence on black hole physics. Further work along this direction is in progress.

(B.S. Ramachandra and C. V. Vishveshwara)

Cosmic GRB energy-redshift relation and primordial flares as possible energy source for the central engine

By extending the solar flare phenomenon to cosmic Gamma Ray Bursts (GRB), we continued the study and established the following GRB energy-redshift relation. By considering similar observed properties of Gamma Ray Bursts (GRB) and solar flares with the prevailing physical conditions in the cosmic environment, the present study suggests that most promising energy source for the central engine which triggers GRB may be due to primordial flares, solar flare like phenomena, at the sites of inter galactic or inter galactic clusters in the early universe. The energy-redshift relation, $E = E_0(1+z)^3$ (where E is the amount of energy released, z is the redshift of GRB and E_0 is a constant which is estimated to be ~ 10^{52} ergs), derived from the simple flare mechanism, is confirmed from the least square fit to the observed energy-redshift data.

(K.M. Hiremath)

Stellar Physics

Some general relativistic and radiation effects on the thermonuclear detonation of carbon in the close x-ray binary system 4U - 1820 - 30 were studied.

(C.Sivaram)

Cosmology

Consequences of quintessence and time varying repulsive interactions with a modified energy momentum tensor for the initial singularities in cosmology were studied. This model gives rise to an accelerative phase at the present epoch.

(C.Sivaram)

Solar polarization

The work on the Theory of Radiative Transfer in Polarized Spectral Lines has been continued. The Physics of Partial Frequency Redistribution (PRD) is explored to highly advanced levels. Several important issues concerning the Angle Dependent PRD, which awaited answers for three decades are resolved. This work opens new vistas in the field of "Solar Polarization".

Polarized line transfer

Iteration over the last few years (see the series of 6 main papers under the common Title: *An Operator Perturbation Method for Polarized Line Transfer*, and several other connected publications, which referred to specific issues). In the 6th Paper of this Series, they have developed a generalized core-wing method (named GPALI) for Hanle Effect with PRD and the collisions. A full account of the Method and its performance can be found in Fluri, Nagendra & Frisch (2002c). This work is useful for treating the Angle Averaged (AA) Scattering Partial Redistribution matrices, in the Hanle Scattering, and has important applications in analysing the *Second Solar Spectrum* of the Sun (the line spectrum in linearly polarized light) formed in weak magnetic fields.

The subsequent, and what happens to be an extremely difficult case, involves developing a line transfer code for 'Angle Dependent (AD) Hanle partial frequency redistribution with Collisions'. This work required the use of supercomputers in Paris. But the outcome of this work has far reaching consequences to the way in which Hanle effect would be employed in the analysis of Solar Weak Magnetic fields. A detailed account of the Method is given in Nagendra, Frisch, & Faurobert (2002d). It is a perturbative method and involves a direct and explicit evaluation of the so called "Angle Dependent scattering integrals". Figure 10 shows the 'Logical Frequency Domains' for a sample of Scattering Angles Θ. The domains depend on incoming and outgoing frequencies (x' and x), incoming and outgoing angles n′ and n, and finally the magnetic field strength and orientation. The functions $R_{III\text{-}AD}$ and $R_{II\text{-}AD}$ represent the type of redistribution (respectively, the non-coherent scattering, and partially coherent scattering in the Lab Frame). The scattering integral is evaluated on 2D frequency domain (x, x′). The Domain 1 and 2 correspond to the weighted combination of isotropic and Hanle Phase matrices, and Domain 3 correspond to the combination of isotropic, Rayleigh, and Hanle phase matrices. The Domain 4 and 5 represent pure Hanle and pure Rayleigh Phase matrices. The weighting coefficients depend on the collisions of different kind (elastic and inelastic).

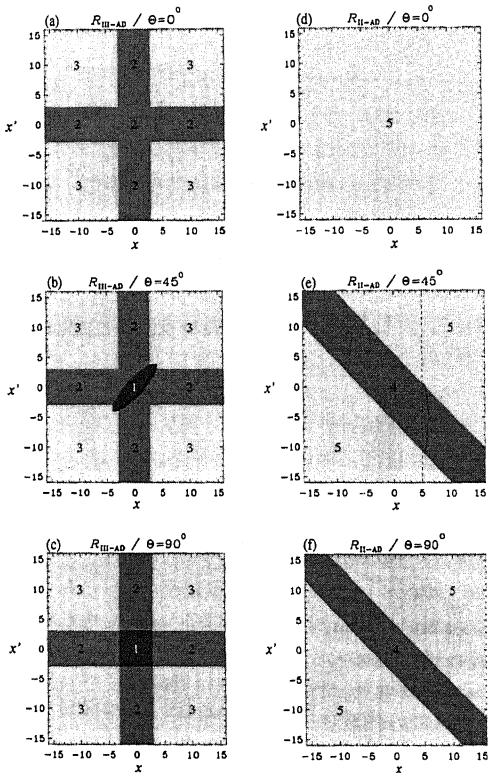


Figure 10 : The frequency domains for solving the Angle Dependent (AD) Hanle redistribution problem. The panels (a), (b), (c) refer to $R_{III\text{-}AD}$ (x, x',Θ), and the panels (d), (e), (f) refer to $R_{II\text{-}AD}$ (x, x',Θ). The domains marked as 1, 2, 3 refer to $R_{III\text{-}AD}$, while those marked as 4, 5, refer to $R_{II\text{-}AD}$. Notice a strong dependence of the domain shape on the scattering angle Θ. The dotted vertical line in Fig. 10e shows the 'line of integration' over frequency x', for a given value of x. The damping parameter $a = 10^{-3}$ is used.

In order to illustrate the transition from the Hanle dominated line core to the Rayleigh dominated line wing, we show, in Figure 11, the Stokes Q and U parameters for pure Hanle scattering, pure Rayleigh scattering and the general case where both are considered. Such a comparison is carried out for both AA and AD cases.

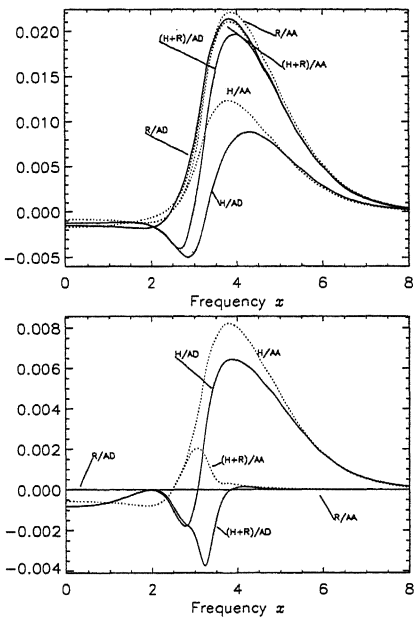


Figure 11 : The emergent Stokes Q and U profiles for pure Hanle (H), pure Rayleight (R), and the general Hanle plus Rayleigh (H+R) scattering mechanisms. The dotted lines represent the AA redistribution. The exact AA and AD frequency domains are employed in the computations. Notice the smooth transition between the Hanle dominated line core and the Rayleigh dominated line wing.

The parameter choice $[T, a, \varepsilon, \beta, B_{v0}] = [2 \times 10^4, 10^{-3}, 10^{-3}, 0, 1]$ characterizes the atmospheric model used in the line transfer computations. We consider the pure R_{II} case with $\alpha = \beta^{(0)} = \beta^{(2)} = 0.999$. The magnetic field is defined by $\Gamma_B = 1.0$, $\theta_B = 30^\circ$ $\varphi_B = 0^\circ$. The medium is assumed to be isothermal and self emitting slab atmosphere characterized by optical thickness T. The atomic model is represented by: thermalization parameter ε; continuous absorption parameter β; the total damping parameter a. The field strength parameter Γ_B is the ratio of Larmour frequency to the radiative width.

The general case of (H+R) clearly follows the Hanle type scattering in the line core ($|x| < 2.5$), and the Rayleigh type scattering in the wings ($|x| \geq 4.5$), for both Q and U. In the AA case, the Rayleigh type behavior for Q, starts even in the near wings ($|x| > 2.5$). We also note that, for both AA and AD, Stokes Q is bounded from above by the Rayleigh limit, and from below by Hanle limit. This is consistent with the fact that the Hanle effect decreases Stokes Q (Hanle depolarization).

As for the U parameter, in the AA case, it follows the Hanle limit in the core and, in the wings, is smaller than the pure Hanle case, as expected. In the AD case, Stokes U also follows the Hanle limit in the line core, but in the wings, there is a more complex behavior.

An analytical derivation is presented to show that 'observing non-zero Stokes U- parameter does not necessarily mean that the Magnetic field is oriented to the symmetry axis of the slab. If the frequency integral over U is also non-zero, then we can conclude that the field is oriented to the slab normal. Redistribution matrices for the Hanle effect containing an angle-dependent frequency redistribution have been proposed recently in the literature (Stenflo 1994; Bommier 1997b). We showed that, these matrices have an unexpected behavior on the Stokes parameter U which becomes non-zero even in an axially symmetric medium!

Numerical work with the Hanle effect, taking into account Partial Frequency Redistribution (PRD) effects has been studied in the last 2 decades using the approximation that frequency redistribution can be described by an Angle-Averaged (AA) frequency redistribution function. This assumption is questionable when resonance polarization or the Hanle effect are considered since it is precisely the anisotropy of the radiation field which is the source of

the polarization. We have shown that it is necessary to use Angle Dependent (AD) redistribution to represent the Hanle scattering effects correctly.

(K.N. Nagendra)

Line formation in the atmosphere of Brown Dwarf Gliese 229B

We investigate the formation of methane line at 2.3 micron in Brown Dwarf Gliese 229B. Two sets of model parameters with (a) T_{eff}=940 K and log (g)=5.0, (b) T_{eff}=1030 K and log(g)=5.5 are adopted both of which provide excellent fit for the synthetic continuum spectra with the observed flux at a wide range of wavelengths. In the absence of observational data for individual molecular lines, we set the additional parameters that are needed in order to model the individual lines by fitting the calculated flux with the observed flux at the continuum. Significant difference in the amount of flux at the core of the line is found with the two different models although the flux at the continuum remains the same. Hence, we show that if spectroscopic observation at 2.3 μ m with a resolution as high as $R \simeq$ 200,000 is possible then a much better constraint on the surface gravity and on the metallicity of the object could be obtained by fitting the theoretical model of individual molecular line with the observed data.

(Sujan Sengupta and Vinod Krishan)

Probing dust in the atmosphere of brown dwarfs through polarization

Theoretical analysis and observational evidences indicate that a brown dwarf with effective temperature greater than 1400 K would have dust cloud in its atmosphere. We show that dust scattering should yield polarized continuum radiation from the relatively warm brown dwarfs and the polarized flux profile could be a potential diagnosis tool for the optical and the physical properties of dust grains. The degree of polarization due to multiple scattering will be more in the optical region if the particle size is small while significant polarization should be detected in the infrared region if the particle size is large (Figure 12). It is pointed out that the departure from sphericity in the shape of the object due to rapid rotation and due to tidal effect by the companion in a binary system ensures the disc integrated polarization to be non-zero.

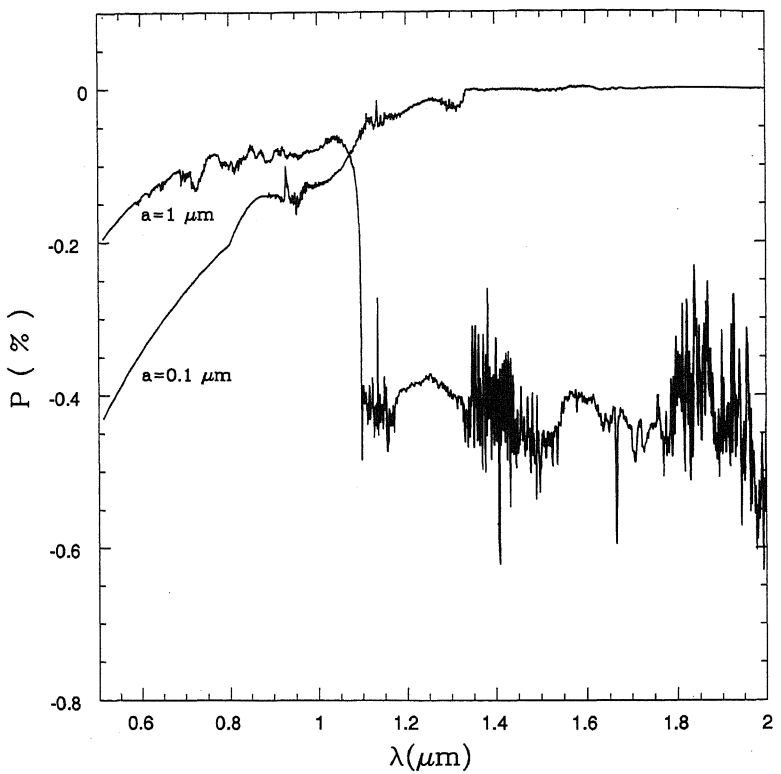


Figure12 : Theoretical estimation of the degree of polarization due to multiple dust scattering in Brown Dwarfs. "a" is the mean radius of silicate grain.

(Sujan Sengupta and Vinod Krishan)

Joule heating of neutron stars under strong gravitation

Considering Joule heating caused by the dissipation of the magnetic field in the neutron star crust to be an efficient mechanism in maintaining a relatively high surface temperature in very old neutron stars, the role of general relativity is investigated. It is found that, although the effect of space-time curvature produced by the intense gravitational field of the star slows down the decay rate of the magnetic field, modification of the initial magnetic field configuration and the initial field strength by the space-time curvature results in increasing the rate of Joule heating and hence supports Joule heating in maintaining a relatively high surface temperature which is consistent with the observational detection.

(Sujan Sengupta)

Tidal forces and spectral line profile variability: Iota Orionis

We predict the possible photospheric absorption line profile variability expected to arise due to the deformation of a stellar photosphere that results from tidally-driven surface oscillation in binary star. The deformation of the primary star is measured in terms of ratio of angular velocities at the equator and pole, mass ratio of two components, the ratio of centrifugal force to that gravity forces at the equator and the ratio of the equatorial radius to the distance between the centers of gravity of the two components. A seventh degree equation is obtained to describe the distorted surface in terms of above parameters. The above equation and the non-LTE two level atom approximation in the comoving frame in spherical symmetry solved simultaneously to get the source functions (Ss). The source function (Sr) due to irradiation from the secondary is calculated using one dimensional rod model. The total source function S=Ss+Sr is used to calculate the line profiles along line of sight. We apply the model to the binary system Iota Orionis a highly eccentric, nearby binary and compare with observations of this system.

(M.S. Rao, G. Koenigsberger*, E. Moreno*)

Formation of supermassive black holes

The presence of quasars at high redshifts tells us that galaxy formation had proceeded far enough for supermassive black holes to form in the standard picture. A detailed model of formation of these objects, such as the one attempted here, should address the issues of supernovae feedback from star formation and the mechanism of efficient angular momentum transport in order to explain the massive active nuclei as early as z=6. In the case of massive dark objects (MDOs), there is a need to explain the compact sizes of 10-100 pc that are implied from dynamical studies.

Mangalam(2001) discussed a detailed physical model for the formation of black holes(or MDOs) from a magnetized accretion of a collapsed disk, the properties of which are obtained taking into account supernovae feedback in a virialized halo. A significant star formation and supernovae activity occurs after the cloud, which is spun up by tidal torques, contracts to a radius where self-gravity is significant.

In a work in progress, we predict the peaks of galaxy formation and quasar formation in the Universe stemming solely from the constraints of cooling processes and this is not very sensitive to the parameters involved. In another work in preparation, we have incorporated radiative viscosity and braking effects during the advanced stages of collapse to a black hole in a cosmological context.

(A. Mangalam)

TeV gamma rays from gamma ray bursts

We have continued our work, began in the previous year, on the possible emission of TeV gamma rays from Gamma Ray Bursts (GRBs), and their detectability. We calculate the expected flux of TeV photons from GRBs within the context of three different possible mechanisms of high energy gamma ray production within GRB sources, namely, (1) photo-pion production by high

energy protons with the MeV-energy photons within the GRB source and the subsequent decay of the pions to photons, (2) inverse compton scattering of high energy electrons on the MeV photons within the GRB source, a process which up-scatters the MeV photons to TeV energies, and (3) synchrotron emission of ultrahigh energy protons accelerated within the GRB source in the strong magnetic field within the GRB source. We calculate in details the optical depth of TeV photons against pair production due to their interaction with the lower energy gamma ray photons within the GRB source and find that, except under certain special circumstances, this optical depth is rather large, indicating that very few TeV photons are likely to escape from the source even if they are produced there. The emerging TeV flux is subject to further attenuation during propagation from the source (which are at cosmological distances) to Earth due to pair production on the intergalactic infrared background photons. Our conclusion is that the resulting TeV photon flux at Earth is generally too small to be detectable by existing detectors, except for unusually bright and very close by GRBs ($z<.01$, say).

(P. Bhattacharjee and N. Gupta*)

Quasar redshifts

An alternative description of the Universe,perhaps more versatile than that given by the standard Friedmann cosmologies,is provided by the Conformal Gravitation Theory Of Hoyle & Narlikar [HN]. As described in an earlier report the Variable Mass Hypothesis [VMH] of the HN theory,in which the expanding universe scenario is replaced by the notion of variable particle masses,can fairly satifactorily explain the observed anomalous redshifts of quasars and various features such as alignments, redshift bunchings and luminous connections of typical quasar - galaxy associations. [Narlikar & Das [Nd,1980],Das [1993,1997]. The work done during the period of the present report critically examines how well the Narlikar-Das scenario stands up to the recent observational data. Towards this end, using the most recent observations from X-ray astronomy by Arp and others,the dynamics of ejection of quasars from galactic nuclei was investigated in the original ND scenario. A consistent picture emerges from the numerical calculations in which a typical quasar starts its life as a young lump of matter ejected from the parent galaxy with the speed of light and zero rest mass. But it quickly slows down as its mass grows with the passage of time. The quasar passes through a continuous sequence of increasing masses and decreasing redshifts. Depending on the initial energy of ejection the quasar may altogether escape from the gravitional influence of the parent galaxy or form a bound system with the galaxy moving in steadily shrinking orbits around it. The calculation gives a method of deciding which quasars are bound.

Another problem which was and is being investigated is the appearance of peaks in the redshift distribution of quasars [Quantization or Periodicity of Redshifts] which does not have a satisfactory explanation in standard cosmology. In terms of the VMH quantization of redshifts implies mass quantization.It is argued that the nucleus of the parent galaxy becomes unstable whenever the created mass attains one of a discrete set of values and ejects the same. Work is in progress, quanti-fying this idea and using it to understand the periodicity found in the redshifts of ejected quasars.

?.K. Das)

Physics and mathematics

Studies on astrophysically important atomic processes

The understanding of basic facts about nature is the foremost goal of the science. We try to use ideas, concepts and laws of physics to answer these questions. Much of what we know about the forces and interactions in atoms and nuclei has been learned from scattering experiments and theories, e.g. Rutherford's experiment on alpha(α) ray scattering.

A. Positron and Positronium Physics

Positronium-Atom Scattering : One of the most popular discoveries in science is the existence of positron(e^+), the antiparticle of electron(e^-) by Anderson in 1932. Again the theoretical prediction of the existence of Positronium(Ps) , the bound state of a positron and an electron by Mohorovicic(1932) and Ruark(1945) led to the experimental discovery of Ps in 1953 by Deutsch. The interesting property of this particle is that it is an isotope of hydrogen, whose charge and mass centers coincide and at the same time it is itself its antiparticle.

Recent astrophysical observations of high energy spectra from various sources: from solar flares, from both the interstellar medium and a variable compact source in the general direction of the galactic center, from gamma-ray bursts have proved existence of 0.511 MeV photons. The characteristic three photon continuum resulting from ortho-positronium has also been observed from the direction of galactic center. At the same time the existence of elecrons and positrons in the astro-ambient medium has increased the importance of theoretical studies on positron-atom and Ps-atom scattering.

(a) Ionisation : Three different types of ionisation in Ps and atom scattering have been studied for the first time. The most reliable Coulomb-Born approximation is used in analytical approaches in the following Ps-atomic systems:

(i) Ps-H system;
(ii) Ps-He system;
(iii) Ps-Li system.

Ionization is the most important reaction process in positronium(Ps) and atom scattering. At very low energies below threshold, elastic scattering is important. The effect of exchange is negligible at intermediate and high energies. At the incident energies well above threshold there is almost no effect of exchange. For obtaining a complete picture about the dynamics of positronic systems, it is essential to do studies on ionization with targets of different nature. In this context, H is an ideal system where exact wavefunctions are known. He is the simplest closed shell atomic system and Li is the simplest among the alkali atoms. Alkali atoms have a very high polarizability(almost 30 times more than hydrogen), whereas in He it is less important. The problem is challenging due to the facts that it is very difficult to perform analytical calculation involving Ps and complex atomic systems makes the problem more complicated. Different types of atomic wavefunctions are used for a particular target atom.

(b) Elastic Scattering : Ps-H system is a system of great fundamental importance since beginning of this field. There is no experimental data for this system. But there is no question about the theoretical acuteness of the problem since both, Ps and H are ideal systems and the atomic wavefunctions are perfectly known. In practice it is very difficult to carry on theoretical calculation to find basic physics through scattering studies since an infinite number of channels are open which need to be considered. But to search new

physics, the scattering phenomenon is most desirable. It is likely to study scattering phenomenon at the energy region below threshold where all the other channels are closed except the elastic one. Again at very low energy region, the system is highly complicated due to the fact that other effects like exchange of electrons, mutual polarization e.g. Van der Waals interaction , etc. have significant contributions. The close coupling approximation(CCA) methodology prescribed by Massey in 1932 is one of the most useful tool to study low energy scattering phenomenon. We have adapted this methodology in the Ps-H system where the wavefunctions of the initial and final channels are coupled through good quantum numbers in the Eigen state expansion methodology.

In Ps-H system, Ps is highly polarizable atom; its polarizability is eight times higher than normal hydrogen atom. It is most essential to include the effects of these polarizing forces for both of Ps and H. In the present study, our motivation is to include effects of these forces due to polarizability together with exchange and to study different scattering parameters to find basic physics.

B. Theoretical studies on atomic transitions

The studies on atomic transitions is a subject of considerable interest in many fields. Extremely hot environment of the stars (for instances, corona of the sun, planetary nebulae etc.) show abundances of highly stripped ions. With the advent of many high resolution spectrographs, observation of weak or forbidden transition lines becomes possible and they are of great astrophysical interest. Many astrophysical phenomena like coronal heating, evolution of many chemical composition in the stellar envelope, determination of the chemistry in the planetary nebulae precursor's envelope are believed to be explained largely by these forbidden lines.

The study of transition probabilities also plays an important role in astrophysics in the determination of atomic abundances. In controlled thermonuclear reactions, atomic radiation is one of the primary loss mechanism. In laboratory tokamak plasmas and in various astronomical objects, suitably chosen electric quadrupole (E2) forbidden lines serve as a basis for reliable electron density and/or temperature diagonostics. Accurate estimates of radiative transition probabilities among multiplet states are an important source for successful experimental identification of the spectra of astrophysical and laboratory plasma. Probabilities of magnetic dipole and electric quadrupole transitions, in particular, are important in plasma diagonostics, but experimental determination of these quantities is difficult, and accurate theoretical calculation only can provide important information.

More accurate studies are performed to find the term values and electric-quadrupole transitions for the highly stripped Na-like iso-electronic sequence of the iron group ions: (i) FeXVI, (ii) CoXVII and (iii) NiXVIII.

C. Theoretical studies on parity non-conservation in Atoms

I have started some new studies on atomic parity non-conservation using many-body theories of atoms. I have already performed some studies on parity non-conservation in Caesium(Cs) atom caused by the nuclear anapole moment using configuration interaction approach.

For doing such studies to find basic physics, heavy atomic systems are more suitable. On the other hand, in heavy systems the accuracy of the atomic function is a great problem due to the strong Coulomb correlation and the relativistic effects. However, Dirac-Hartee-Fock wave functions can be used to include the relativistic effect, but proper inclusion of Coulomb correlation effect is a question. Many-body coupled-cluster method(CCM) is one of such tool which is very successful in alkali-like structure. I am looking for more accurate results by improving the basis with both bound and continuum orbitals and using CCM methodology.

(Hasi Ray)

Relativistic top-down sceneraio of origin of extreme energy cosmic rays

The observed Extreme Energy Cosmic Rays (EECR) – those above 10^{20} eV – are difficult to explain within the standard scenario of acceleration of charged particles in powerful astrophysical objects. The difficulties are two fold: First, it is extremely difficult to accelerate particles to energies above 10^{20}eV even in the most powerful known astrophysical objects by means of known acceleration mechanisms; and second, no suitably powerful astrophysical objects are found in our cosmological neighbourhood within a distance of ~ 60 Mpc – the limiting source distance imposed by the condition that the particles survive the catastrophic energy loss due to their interaction with the cosmic microwave background photons enroute from the source to Earth.

An attractive way to resolve this puzzle of EECR is to postulate a "Top-Down" scenario in which EECR particles arise simply from decay of some sufficiently massive "X" particles (presumably originating from certain fundamental processes in the early universe) with mass $m_X \gg 10^{20}$ eV, rather than from any "bottom-up" acceleration mechanism. Since the X particles need not necessarily be associated with any active and/or powerful astrophysical objects, the absence of any nearby powerful astrophysical sources of the EECR is not a problem in the Top-Down scenario. Much work has been done on the top-down scenario, the predictions of which will soon be testable in the up-coming large area cosmic ray detectors currently under construction.

The Top-Down scenario has so far been considerd with non-relativistic but supermassive X particles with mass $m_X \gg 10^{20}$ eV. However, from the energetics point of view, particles with energy above 10^{20} eV can also be produced from the decay of much lighter ($m_X \ll 10^{20}$ eV) but highly relativistic particles with sufficiently high Lorentz factor Γ such that $\Gamma m_X \gg 10^{20}$ eV. Indeed, in many realistic models of X particle production, in particular those involving cosmic topological defects such as cosmic strings, the resulting X particles are, in fact, highly relativistic. This raises the interesting possibility of seeking a Top-Down origin of EECR without necessarily invoking new physics at superhigh energy scale such as Grand Unified Theory.

In this work, we develop a general formulation of a Relativistic Top-Down scenario of origin of EECR, and find several new features not present in the standard non-relativistic Top-Down scenario, such as the possibility of multiple events from a single X particles (due to $1/\Gamma$ beaming effect). We predict the detailed nucleon, photon and neutrino spectra in this scenario that will be testable in the up-coming large area cosmic ray detectors.

(P. Bhattacharjee, *G. Sigl and *A. Olinto)

Atomic Physics

I am developing Fock-space based atomic and molecular relativistic coupled cluster codes to study the parity non-conservation effect on molecules containing heavy atom. I will be applying this method to compute the excited and ionized state properties as well as PNC effect of molecules containing heavy atoms such Rb_2, CsF, TlF, YbF etc.

In Many Body perturbation theory, the choice of virtual orbital and orbital energies plays the most significant role to achieve rapid convergence. Although this is a well developed subject, we have recently shown an elegant but computationally inexpensive scheme to generate the improved virtual orbitals that are most suitable for describing the excited state of interest. The virtual orbitals generated in our scheme not only provides accurate transition energies but also provide rapid perturbative convergence.

(Rajat Chaudhuri)

We have undertaken a DAE (Department of Atomic Energy) project on Atomic Parity violation and have made significant progress on it. We have also proposed an Indo-Hungarian project which will be mostly focused on the advanced computational approaches to many-electron systems.

(Rajat Chaudhuri and Bhanu Das)

Physics Beyond the Standard Model

We have worked on problems on atomic probes of physics beyond the Standard Model and atomic astrophysics during the past year.

Atomic Probes of Physics Beyond the Standard Model

Parity Nonconservation (PNC) in atoms due to neutral weak currents and electric dipole moments(EDMs)arising from violations of parity and time-reversal symmetries are two important non-accelerator probes of the Standard Model of elementary particle physics.

(i) PNC in Atoms : We have made considerable progress in theoretical studies of properties of Ba+ that provide important insights into PNC in that ion.Important relativistic coupled-cluster calculations for a variety of transition amplitudes and magnetic hyperfine constants for a number of states have been carried out. We have completed our theoretical formulation of caesium PNC and are developing sophisticated computer codes to calculate parity nonconserving observables.

(Bijaya Sahoo, Geetha Gopakumar, Holger Merlitz, Sonjoy Majumder, Rajat Chaudhuri and B.P. Das)

(ii) EDM of Atoms : We have successfully carried out our formulation and computation of mercury EDM in the coupled-perturbed Hartree-Fock and random phase approximations.We are in the process of combining this work with coupled electron pair approximation calculations.The result of our work in combination with the experiment on mercury EDM can provide unique information about CP violation in the hadron sector.

(K.V.P. Latha, Rajat Chaudhuri, B.P. Das and Angom Dilip Singh)

Atomic Astrophysics

A knowledge of forbidden transition probabilities is very useful in a number of situations in astrophysics. Using the relativistic copupled-cluster method we have determined the electric quadrupole transition probabilities in singly ionized magnesium and calcium.

(Sonjoy Majumder, Geetha Gopakumar, *Holger Merlitz, Rajat Chaudhuri, B.P. Das,*U.S. Mahapatra and *D. Mukherjee)

Molecular electronics

Temporal properties of two-wave mixing in photorefractive $BaTiO_3$

Barium titanate is an important photorefractive crystal that has been under intensive study in recent years. Due to its versatility it has been used in various applications like optical image amplification, signal processing, self-pumped phase conjugation, optical resonator in lasers and associative memories etc. This has been possible because of its attractive photorefractive properties such as high values of electro-optic coefficients, fast response time and excellent phase conjugate reflectivity. Large electro-optic coefficient allows one to achieve very high gain coefficient in two-beam coupling. Applications like real-time holography or optical phase conjugation used in distortion correction in time varying distortive media require a very fast photorefractive response of the crystal. Response time depends on the input beam intensity; however, the beam fanning and light-induced absorption can deplete pump as well as signal beam intensities. Therefore, it is vital to study these limiting factors that can restrain the photorefractive performance of the crystal in various applications. We have studied the effect of light-induced absorption over an intensity range of 0.01 to 5.3 Wcm^{-2} and 0.04 to 3.5 Wcm^{-2} at a wavelength of 514 and 488 nm respectively. Experiments have also been carried out to study the grating build-up and decay time scales as a function of beam intensity ratios (Is/Ip), grating period, and pump beam intensity (Ip).

A standard two-wave mixing set up is used to study the grating build up and decay characteristics of undoped and rhodium-doped $BaTiO_3$ crystals. The light source used is frequency-stabilized argon-ion laser (Spectra Physics Model-2085) at 488 and 514 nm. Linear polarizers are used to maintain the vertical polarization of the light. The refractive index grating is written inside the BaTiO3 by pump beam (Ip) and signal beam (Is). The intersection angle

between the two beams in air is 30°. The direction of C-axes is chosen so that energy is transferred from pump beam (Ip) to signal beam (Is) during the grating build up. The rate of energy transfer from Ip to Is is the same as the rate at which the magnitude of space-charge field Esc (so is the refractive index grating) builds up in the crystal. By monitoring the intensity of signal beam as a function of time directly gives the grating formation time. Output signal is detected by multi-channel optical power meter (Newport Model 4832-C)) configured to PC using LabVIEW.

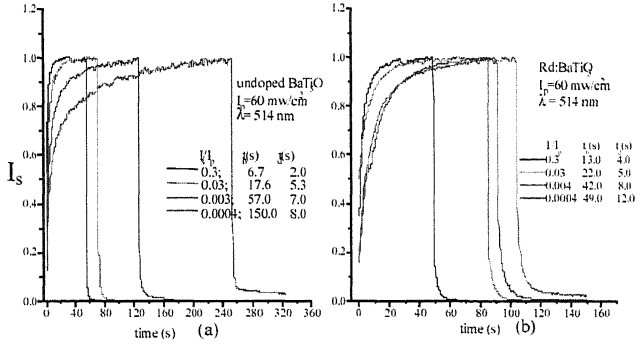


Figure 13 : Grating build up and decay times for different intensity ratio (a) for undoped and (b) for Rd doped BaTiO3 crystal.

Fig. 13. (a) and (b) shows grating build up and decay in undoped and rhodium-doped $BaTiO_3$ crystals. Pump power in both the cases is 5mW (i.e. Ip=60 mW/cm^2). Signal power is varied to study the formation (tb) and decay (td) times at four different intensity ratios (Is/Ip) as shown in each figure. For convenience we have defined grating build-up time tb as the time signal beam takes to reach 95% of its maximum value (i.e. the steady- state or saturation intensity). After reaching the steady state, signal beam (Is) is blocked by electronic shutter, and intensity of the diffracted pump beam is recorded as function of time. It is indicated by sharp falls in intensity followed by exponential decay in the Fig. 1. Therefore, td is the grating decay time defined for the diffracted beam to reduce to 5% of saturation intensity in the absence of signal beam. Intensities are normalized in each case. From Fig. 13, we notice that for every decrease in intensity ratio by a factor of ten in undoped $BaTiO_3$, response time (tb) increases approximately by a factor of three. Comparing the two Fig. 13. (a) and (b), we also notice that the response time of undoped $BaTiO_3$ is faster at higher intensity ratio than the rhodium doped $BaTiO_3$, whereas reverse is true at smaller intensity ratios. Refractive index grating written at lower intensity ratios is found to decay slowly compared to the those written at higher intensity ratios. This behaviour is marked by the increase in decay time (tb) for lower intensity ratios. A similar response is noticed at different pump intensities.

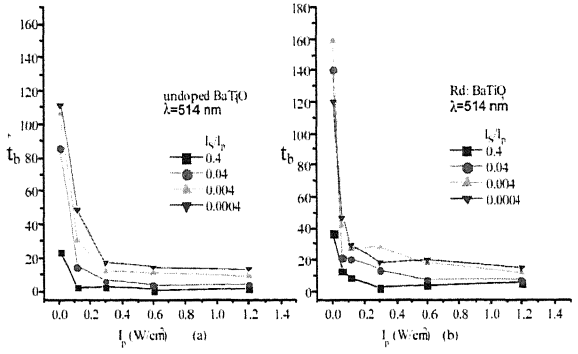


Figure 14 : Grating build up and decay times for different intensity ratio (a) for undoped and (b) for Rd doped $BaTiO^3$ crystal.

Dependence of build-up time (tb) on the pump beam intensity (Ip) measured at different intensity ratios is shown in Fig. 14. We notice that for each intensity ratio, the response time (tb) increases with decrease in pump beam intensity (Ip), however, this dependence is more distinct at low pump intensities. As an example, in Fig. 14(a)., at Ip=.012 W/cm^2 the difference in build up time (tb) for intensity ratios 0.0004 and 0.4 is 87s, whereas at Ip=1.2 W/cm^2 it is just 12s.

(Ravinder Kumar Banyal and B. Raghavendra Prasad)

Singlet and triplet different cross-sections for p p → p p π^0

The singlet and triplet differential cross-sections for p p → p p π^0 have been estimated for the first time at 325, 350, 375 and 400 Me V using the results of the recent experimental measurements [Phys.Rev C63, 064002 (2001)] of Meyer et al. at the PINTEX facility.

(P.N. Deepak* and G. Ramachandran)

Radiative capture of neutrons by protons

A model independent irreducible tensor approach to p(n, γ)d is presented and an explicit form for the spin structure of the matrix M for the reaction is obtained in terms of the Pauli spin matrices $\vec{\sigma}(n)$ and $\vec{\sigma}(p)$. Expressing the multipole and amplitudes in terms of the triplet → triplet and singlet → triplet transitions, we point out how the initial singlet and triplet contribution to the differential cross-section can be determined empirically.

(G. Ramachandran and P.N. Deepak*)

Model-independent estimates of the singlet and triplet differential cross-sections for $pp \rightarrow pp\,\pi^0$

The irreducible tensor approach for nuclear reactions [G.Ramachandran and M.S. Vidya, Phys.Rev C56, R12 (1997) and Invited talk at the 1996 DAE symposium on Nuclear Physics] was employed to discuss the differential cross section for $pp \rightarrow pp\pi^0$ as a function of the five independent kinematical variables [G.Ramachandran, P.N.Deepak and M.S.Vidya, Phys. Rev C62, 011001 (2000)]. A procedure to determine individually the singlet and the three triplet initial spin state contributions to the above differential cross-section was suggested [G.Ramachandran and P.N.Deepak, Phys. Rev. C63, 051001(2001)]. Model independent numerical estimates are presented here based on recent experimental data.

(P.N. Deepak* and G. Ramachandran)

Spin squeezing and quantum correlations

We classify pure states of spin s into oriented and non-oriented states. A state is said to be oriented if it is a simultaneous eigen state of $(\vec{S}.\vec{S})$ and $(\vec{S}.\vec{Q})$ for any choice of $\hat{Q}$ are non-oriented. The oriented states are not squeezed while non-oriented states are shown to exhibit squeezing. A novel scheme is presented for constructing spin s states using 2s spinors oriented along different axes. Considering the particular case of $s = 1$, we show explicitly how squeezing arises from the intrisic quntum correlations that exist among the 2 spinors in the coupled state.

(K.S.Mallesh*, Swarnamala Sirsi*, Mahmood A.A. Sbaih*, P.N. Deepak* and G.Ramachandran)

NAPP Experiments

CCD based high dynamic range optical lever

The work on the line CCD based high sensitivity, high dynamic range optical lever is completed. The dark and bias characteristics of the CCD were studied and the dark count was found to be purely shot noise limited. A software to interface the CCD to a computer and to determine the shift of the image of an illuminated slit on the CCD to 1/100 of a pixel was developed. This sensitivity is achieved even in the presence of background counts amounting to 20% of peak intensity. All aspects of the autocollimating angle measuring instrument is now tested and documented, and it will be used in the measurement of the Casimir force in the range of 10 - 100 microns in the coming few months. An angle measuring sensitivity of about 10^{-8} radian is obtained for integration time of 1 second, and the dynamic range is better than 10^6.

(G. Rajalakshmi and R. Cowsik).

Torsion balance experiment

After initial testing of various sub-systems required to perform the measurement of the Casimir force, the final assembly of the experiment is in

progress. The experiment will be performed in a null mode, with the angular position of the pendulum held constant using torques from capacitors, employing high precision feedback from the autocollimating optical lever signal. To obtain the required accuracy and stability of the torques, a new scheme that provides very stable and minutely variable voltages at the capacitor plates is developed using a voltage source that is pulsed at high frequency and controlled by the feedback from the optical lever. The overall force measurement capability of the scheme is less than 10^{-10} dynes.

(G. Rajalakshmi, R. Cowsik, D. Suresh and C. S. Unnikrishnan).

Atomic beam experiment

We have completed a numerical calculation of the transmission probability of atoms through narrow channels in the presence of the Casimir-Polder force. We had earlier undertaken a Monte-Carlo simulation of the transmission of atoms through such cavities. The analytic technique was initiated to add to our understanding of the dynamics of the atoms flying through the cavity.

The probability was computed over a range of the widths and lengths of the cavity. A similar calculation for probability of transmission in the absence of the Casimir-Polder potential, the geometric transmission, is also carried out. The ratio(R) is a measure of the change in the transmission probability over and above the geometric variation as a function of the cavity length. The entire calculation was numerically carried out using Mathematica. This calculation clearly shows that the effect of the Casimir-Polder force starts to become significant below a cavity width of 3 micron. We also note that errors arising from surface irregularities of the plates and differential thermal expansion and flexure of the support structure could easily affect the measurement of the Casimir-Polder force. Since it is likely that such errors will be difficult to handle if one were to modulate the width of the cavity, the present set up is designed to take data by modulating the length of the cavity with various fixed widths. Precision machined slits for defining the atomic beam, and a beam source based on a glass microchannel array are added to the set up. The vacuum chamber housing the cavity is changed for better access, and entire experiment is being assembled for the final test.

Laser cooling of neutral atoms

A new set of experiments to probe short range forces between laser cooled atoms and surfaces with specific quantum properties is taken up, in continuation of the presently ongoing experiments with thermal neutral atoms. The frequency stabilized diode lasers for this activity has been set up in the TIFR NAPP laboratory using saturation absorption in Rubidium atomic vapour. Initial experiments will use atoms cooled to about 100 microKelvins (average thermal velocity less than 10 cm/s). The magneto-optical trap and the optical dipole trap required to perform these experiments are under construction.

(C.S. Unnikrishnan and *A. K. Mohapatra)

Torsion balance designs for new experiments

One of the most important aspects of high sensitivity experiments using torsion balances is the invention and fabrication of new types of torsion balances to address specific physical problems. In the past we had designed and constructed novel torsion balances for testing the equivalence principle, measuring the Casimir force, searching for short range gravity etc. New designs based on ultra-low torsion constant magnetic suspensions are taken up for constructing new torsion balances for test of the equivalence principle, test of equality of active and passive gravitational mass etc.

(R. Cowsik, G. Rajalakshmi, D. Suresh and C. S. Unnikrishnan).

Gravity and quantum mechanics in the early Universe

The physics of the very beginning of the Universe is expected to be controlled by quantum physics and relativistic gravity together. But, since there is no theory of quantum gravity, there are no predictions that follow directly from the quantum birth of the Universe. We examined the consequences of assuming

that the fundamental principles of quantum mechanics and relativistic gravity were operative during the beginning of the Universe in an essential way. This allows us to determine the initial values of the cosmological parameters like temperature and density in the early Universe entirely in terms of the fundamental constants G, c and h. Then standard Einstein-Friedmann evolution gives the present values. Astonishingly, these evolved values agree well with the observed values, thereby indicating that quantum physics indeed determined the initial conditions of the early Universe. Thus we seem to have observational evidence for a quantum gravitational origin of the Universe.

(C. S. Unnikrishnan, G. T. Gillies* and R. C. Ritter*)

Einstein locality

Our proof of Einstein locality in quantum mechanics is now on a rigourous footing. Essentially, it is shown that quantum theory that incorporates state reduction (collapse of the wavefunction) as a physical phenomenon during measurements is inconsistent with its own mathematical formalism. New quantum optical experiments that can test this conclusively are proposed.

(C. S. Unnikrishnan).

Equivalence principle and quantum mechanics

There have been several suggestions and speculations that quantum matter might violate the equivalence principle of gravity. The reasons that lead to such suggestions have benn based on the absence of the concept of trajectories in quantum mechanics, basic constraints on localization imposed by the uncertainty principle etc. A proof for the validity of the equivalence principle for all quantum matter, assuming its validity for classical matter was obtained. The proof relies on the fact that the dynamics of the quantum matter between two instants of time is determined by the classical action in the path integral. Therefore, the validity of the equivalence principle in the classical regime is sufficient for its validity in the quantum regime.

(C. S. Unnikrishnan)

Mathematics

A preliminary version of a monograph on "some applications of valuation theory" was prepared and submitted to the UGC in November 2001.

This starts with a brief introduction to general valuation theory and discusses in some detail Henselian fields. There is also an outline of recent work on valuations in non commutative situations especially the work by Draxl, Tignol and Wadsworth. As applications of valuation theory there are three distinct problems which are comprehensively considered.

1. The work of B.Dwork on the rationality of the Zeta function of a variety defined over a finite field. This work establishes one of the three conjectures of Andre Weil in the affirmative using p-adic analysis.

2. The work of J.Ax and S.Kochen on Diophantine Problems. This disproves a conjective of E.Artin using methods of valuation theory and ultra product of valued fields. Here we need valuations of higher rank.

3. The work of V.Platanov on the Artin - Tannaka problem. This disproves a conjective of E-Artin on the triviality of the reduced Whitehead group. Platanov using valuations of rank 2 constructs division algebras with non-trivial reduced Whitehead groups.

(N. Sankaran)

Instrumentation and facilities

The Ultraviolet Imaging Telescope Project

The UV Imaging Telescope (UVIT) has been proposed as a key instrument on board the ASTROSAT mission. The UVIT will have a primary aim of conducting an all-sky multiband survey in the wavelength region $\lambda \sim 1300\text{-}3000$ Å. Imaging surveys of the sky have been done in all wavelength bands except the UV. Several short missions in the past using high altitude balloons, sounding rockets and shuttle launches have demonstrated the power of UV imaging in providing new insights into the areas of hot stars and stellar evolution, star formation in galaxies, galaxy evolution, active galactic nuclei (AGN) and quasars. The primary advantage in the UV is that the sky background from space is extremely low and that the emission from objects such as hot stars, starbursts, AGN and quasars peaks in the UV region. During the anticipated mission lifetime of ~ 5 years, apart from the all-sky survey, there will be time for simultaneous X-ray/UV monitoring of X-ray binary stars, cataclysmic variables, AGNs and quasars. A variety of guest observer targetted programs will also be accommodated. The UVIT will have slots to accommodate wide band filters for the survey as well as narrow-band filters (emission lines and continuum points).

Detailed studies of various telescope configurations with a view to balancing scientific viability and engineering reliability have been going on over the past 2 years. The initial design of a single telescope with two UV channels has been abandoned in favour of two smaller telescopes (aperture 40 cm) optimised for the two UV ranges (100-200 nm and 200-300 nm). The loss due to collecting area is lesser than that due to the UV-UV beamsplitter originally envisaged. A beamsplitter in the near-UV (200 - 300 nm) telescope would be used to accommodate an optical channel necesary for field identification and aspect determination. Figure 15 shows a 3 dimensional view of the proposed telescope structure.

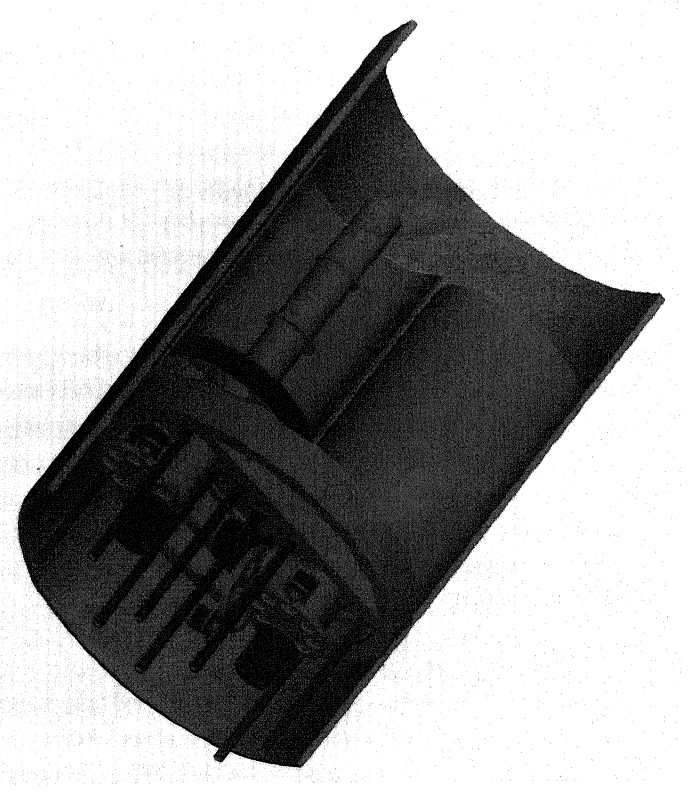


Figure 15 : A 3-D cutaway section of the UVIT telescope shown as mounted within the central cylinder of the Indian Remote sensing Satellite bus (outer gray cylinder). One of the UVIT tubes is cutaway to show the primary mirror and baffle tube. The upper end of the telescope tubes with secondary mirror is not shown. The lower part of the figure shows the location of the filter wheel assemblies and detectors.

The optical design of the twin telescopes aims at a final resolution on the sky of ~ 1 second of arc. The design has been fixed in keeping with the detector resolution that could be available.

Discussions on technical aspects such as filter mechanisms, mechanical structure, instrument stability at launch, electronics systems, satellite pointing accuracy and tracking stability, data rates for telemetry, on-board memory requirements and a variety of related issues have been held with groups at ISAC. The mechanical design of the UVIT telescopes is a challenging task, since the structure has to maintain the stringent alignment of the optical elements through the rigours of launch. The preliminary mechanical structure design has been done and analysis of the structure (vibrational and thermal) has commenced.

The detectors proposed for use in UVIT are photon counting tubes employing microchannel plate intensifiers coupled to CCD readouts. The UVIT team has been closely interacting with scientists at the Dominion Astrophysical Observatory (Victoria, Canada) who have expressed interest in the project. Their technical knowhow and experience will be invaluable for realising the detector systems. The collaborators have visited IIA twice and they have submitted a proposal to the Canadian Space Agency for funding of the detectors as part of the collaboration.

Conceptual design of the required support facilities for integration and testing of the UVIT payload at the component, subsystem and fully integrated level has been done. This would involve building a clean laboratory with different portions having clean room class of 100000, 10000, 1000 and 100 for various stages of integration and calibration. A large vacuum chamber for testing and calibration of the telescope in the ultraviolet is also proposed to be built.

The team members working on the UVIT project and the areas of major responsibility at the present time are : N.K. Rao (PI), A.K. Pati (Co-PI & Mechanical), J. Murthy (Project Scientist & Detectors), A.K. Saxena (Optics), B.R. Prasad (Calibration) and P.K. Mahesh (Mechanical). The team has faced several rounds of reviews by technical evaluation committees constituted by ISRO. Detailed reports of the UVIT project for the various subsystems have been prepared and submitted to ISRO.

(A.K. Pati)

Speckle Interferometer

The new speckle interferometer has been in operation since 1996, at the Cassegrain end of the 2.34 meter Vainu Bappu Telescope (VBT), Vainu Bappu Observatory (VBO), Kavalur to record speckle-grams of various objects, viz., close binary stars ($\rho < 1''$), active galactic nuclei etc. Recent development of the solid state based non-intensified low light level CCD (L3CCD) which effectively reduces readout noise to less than one electron rms has enabled substantial internal gain within the CCD before the signal reaches the output amplifier. We have procured one such CCD from Andor Technology recently for recording specklegrams of faint objects at the VBT, Kavalur. This system has 576X288 pixels of size 20X30μm in the image area. It is provided with Peltier cooling system that operates to -65° C with air-cooling and with further additional water circulation, it reaches -80°C. The performance of this cooling system is comparable with liquid nitrogen cooled cryostats.

L3CCD is a frame transfer device where the image store and readout register are of conventional design that operates typically at 10 volts. But there is an extended section of gain register between the normal serial register and the final detection mode which operates at much higher amplitude (typically at 40-50 volts). This large voltage creates an avalanche multiplication which thereby increases the number of electrons in the charge packets, thus producing gain. Adjustment of gain is possible with fine control of the voltage. All the output signals above a threshold may be counted as photon events provided the incoming photon flux is of a sufficiently low intensity that no more than

one electron is generated in any pixel during the integration period, and the dark noise is zero, and gain is set at suitable level with respect to the amplifier read noise. The L3CCD at our Institute has the provision to change gain from 1 to 1000 by software. The noise at 1 MHz read rate is 0.1e. Each pixel data is digitized to 16 bit resolution.

We have tested this L3CCD both at the laboratory, as well as at the 2.34m VBT, VBO, Kavalur. The performance was found to be satisfactory. The dark count was found to be 0.001 e/pixel/second at -80°C and the saturation signal was about 52, 000 counts/pixel. Without external power supply and using the internal PC power, the Peltier cooler reached the set temperature of $-50^{\circ}C$ from the ambient temperature of $20^{\circ}C$ within 11 minutes. On 15th December, 2001, we have recorded an image of the star, HD36151, $m_v \simeq 6.5$ at the Cassegrain focus of 2.34 m VBT, VBO, Kavalur, with an exposure time of 10 msec, software gain set to 150, and CCD sensitivity of 6.14 e per A/D count. The recorded image shows 50,000 counts. A 12th magnitude star with integration time of 10 msec. has been recorded as well. The count was found to be about 2000.

(S.K. Saha, V. Chinnappan and L. Yeswanth)

Close binary stars : Thousands of speckle-grams of several close binary stars and of reference stars (unresolved) were successfully recorded with the speckle interferometer at VBT through the narrow band filters, using the Peltier cooled ICCD camera system as detector. A few binary systems have been recorded by employing the new low light level CCD (L3CCD) as well. The quality of the data was found to be satisfactory. Data of two close binary stars, HR4891 and HR5298 alongwith the respective reference stars were processed. More than 400 frames of each of these stars are scanned carefully and are used for analyzing. The separation of the components of HR4891 and HR5298 are found to be 0.094″ and 0.309″ respectively. These results are consistent with the CHARA catalogue. A new algorithm is being developed for triple correlation, where a Wiener parameter is added to point spread function (PSF) bispectrum. This algorithm will enable us to estimate Fourier phase of a binary system with a few realizations.

(S.K. Saha)

Active galactic nuclei : An important field of observational astronomy is the study of the physical processes, viz., temperature, density and velocity of gas in the active region of the active galactic nuclei (AGN). High resolution optical imaging in the light of emission lines on sub-arcseconds scales can reveal the structure of the narrow-line gas. Another important phenomenon – the time variability of AGNs, ranging from minutes to days can also be studied. The specklegrams of the AGN, NGC4151, obtained at 2.34 meter VBT, are being processed.

(S. K. Saha)

Measurement of r_o : The night time variations of Fried's parameter at the 2.34 meter VBT site were computed using the speckle interferometric technique. Speckle-grams of 15 point source (unresolved stars) in and around 30° zenith were analyzed. The form of transfer function $\langle|\hat{P}(\mathbf{r})|^2\rangle$ is obtained by calculating Wiener spectrum of the instantaneous intensity distribution from each of these stars. Here, $\hat{P}$ is the transfer function, $\mathbf{r} = (x, y)$ is 2-dimensional space vector, $\langle\rangle$ indicates the ensemble average and $||$ stands for the modulus. Further analysis has been carried out at an interval of 1 minute; measurement of r_o at a step of ~ 0.1 sec is also in progress.

(S. K. Saha, L. Yeswanth, and V. Chinnappan)

Mechanical engineering division

The following are the works carried out at the Mechanical Design Section, Bangalore and the Mechanical Workshop, Vainu Bappu Observatory, Kavalur.

1. Ultra-Violet Imaging Telescope (UVIT) on ASTROSAT : An Ultra-Violet Imaging Telescope (UVIT) is proposed to be launched on board an Indian remote sensing Satellite (IRS) bus named ASTROSAT by a Polar Satellite Launch Vehicle (PSLV) of the Indian Space Research Organisation (ISRO).

The design of the structure for UVIT and its mechanisms like filter wheel and participation in the detailing of the testing facility for the same were carried out.

2. Gamma ray telescope : An array of gamma ray telescopes is proposed to be installed at the Indian Astronomical Observatory, Hanle. The mirrors (900mm) and detectors [Photomultiplier tubes, (PMT's)] are being supplied by the collaborating institution, the Tata Institute of Fundamental Research (TIFR).

The preliminary design of an array of gamma ray telescopes was completed. It is proposed to use an altitude over azimuth mount for the structure and a worm gear and helical gear unit driven by stepper motor for the drive.

3. 75cm telescope : The present mount and drive for the 75cm telescope at Vainu Bappu Observatory, Kavalur is not found to be optimal.

It is proposed to make a design for a new mount for the 75cm telescope based on the one made for the 61cm Schmidt telscope viz. an equatorial (yoke) mount and a combination of a worm and helical gear drive.

4. Multi Aperture Solar Telescope (MAST) : A design study for a Multi Aperture Solar Telescope (MAST) was carried out for Udaipur Solar Observatory and a report on the same was prepared.

The Multi Aperture Solar Telescope is a set of plane mirrors mounted on a common platform base. Two sets of these are being planned. One has the aperture of the mirror fixed as 60cm and the other is 15cm. 6nos. of 60cm mirrors and 24nos. of 15cm mirrors form the two MAST units. An altitude over azimuth mount and a suitable drive has been considered.

5. Shielding Panels for the Gravitation Experiment faciltity at Gauribidanur : In order to control the temperature at the Gravitation Experiment faciltity at Gauribidanur, a set of panels was designed and manufactured for enclosing the experimental setup.

6. Coudé Echelle Spectrograph for the Vainu Bappu Telescope : The pending works in the Coudé Echelle Spectrograph for the Vainu Bappu Telescope including the precision air-conditioning of the enclosure was completed and the instrument put into operation.

7. Indian Astronomical Observatory, Hanle : The modified drive system for the dome housing the 2m optical telescope was designed, manufactured and installed and is now working satisfactorily. The pending work at the dome to house the 50cm telescope was completed.

8. Design of secondary unit for the Vainu Bappu telescope : The present system for the secondary mirror of the Vainu Bappu telescope has not been found to be optimal.

A new system for the same has been designed and analysed by two undergraduate students of Mechanical Engineering as their final year project under the guidance of P.K. Mahesh and P.M.M. Kemkar. The drawings were done with the drafting software Mechanical Desktop 5.0 (MDT 5.0) having AutoCAD 2000 as its kernel and the analysis was done by the recently acquired finite element analysis software, Nastran for Windows.

(P.K. Mahesh)

Computer Centre

1) A shared 64 Kbps vsat link to VBO, Kavalur was installed by Ms ITI, Bangalore. This link will provide access to email and the internet from Kavalur. It has one voice channel and one data channel.

2) A dedicated 768 Kbps RF link was set up by M/s Primus Telecommunciations Private Ltd., Bangalroe for accessing the internet. This will provide faster access to the Internet. This is in addition to the existing 128 Kbps ERNET link, provided by M/s STPI, Bangalore. The new link is particularly useful for bulk data transfer.

3) As the IIA computers were hacked by outside elements in recent times, there was a need for a firewall and they are protected from hackers. M/s Excore have also set up the VPN (Virtual Private Network) services and Webmail option on the email server for accessing systems on the LAN from outside in a secure way. IIA's ftp server and web server were also moved behind the firewall.

4) A five user, network licensed IDL software was installed on the Sun Workstations for general use. This package is widely used by the scientists and students for graphics and image analysis.

5) The present Loca Area Network at IIA, Bangalore campus is nearly a decade old and it is built on the thin Ethernet coaxial cable technology. It is proposed to upgrade the Local Area Network to the UTP switching technology with Giga byte switches. A suitable vendor is being identified for installing the new network in the IIA Bangalore campus shortly.

(J.S. Nathan, S.S. Chandramouli, A.V. Ananth)

The software for the 75cm telescope at Kavalur : In the light of the experience we have gathered from the 2m. telescope at Hanle, it was found desirable to develop software for the 75 cm telescope as a sample case. The software architecture has been choosen to be identical except for changes required for bulk data handling. The preliminary work on the Turbo-Pmac hardware from Delta Controls USA has been initiated for telescope control. Efforts are also on to identify and procure items like motors, encoders and mechanical elements required for project implementation.

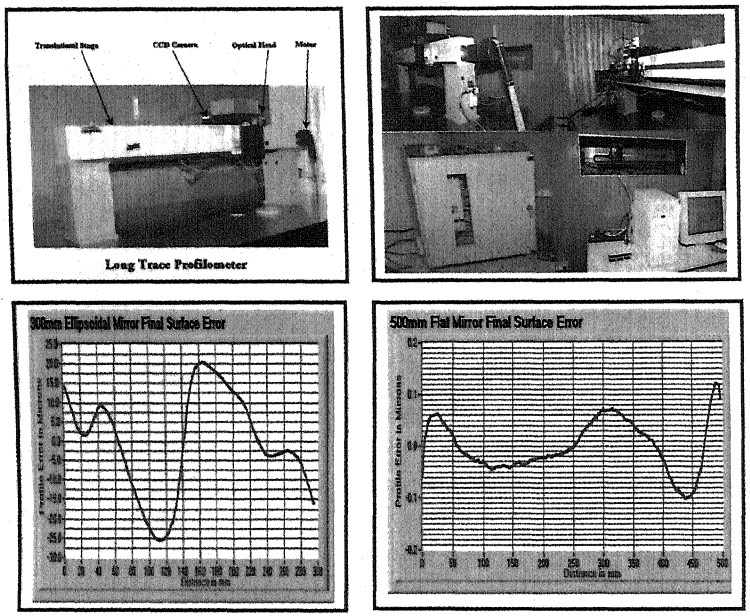
(A.V. Ananth, Anbalagan, Anil Raut, Ravi)

Photonics Division

102 cm telescope : The fabrication work on the 102 cm primary mirror of the 102 cm telescope has been completed. A new null optics has been designed and fabricated. The 102 cm mirror was tested with the null optics and records were obtained. The mirror is being compared with the existing 102 cm mirror at VBO.

Long Trace Profilometer (LTP) : The construction of the Long Trace Profilometer (LTP) has been completed. This facility has been set up at the Institute under DAE - BRNS project to meet the requirement of grazing incidence optics, used in Synchrotron Beam Lines, during fabrication and evaluation from time to time. The Long Trace Profilometer (LTP) is now operational. It is capable of measuring 900 mm long strip mirrors (flat, spherical, ellipsoidal or other aspherics) with an accuracy of 0.30 arc sec in terms of slope error and 1.5 nm in terms of surface height for segment length of 1 mm. The instrument is fully computer controlled. This is one of the very few instrument available now in other labs around the world. The pictures here show the instrument details and profiles of the calibration mirrors measured using the same. The facility is now available for measurements by external users also.

VHRR sunshield panels : Work on another set of VHRR sun shield panels for METSAT has commenced from April 2001. Also, the work for INSAT 3D is progressing well. Two new sophisticated polishing machines and Veeco profilometer for measuring micro roughness to an accuracy better than 1.5 to 2 Å have been added to the facility for this work. The new set of



panels have larger dimensions compared to the previous sets. Necessary fixtures to suit this dimension have been designed and fabricated.

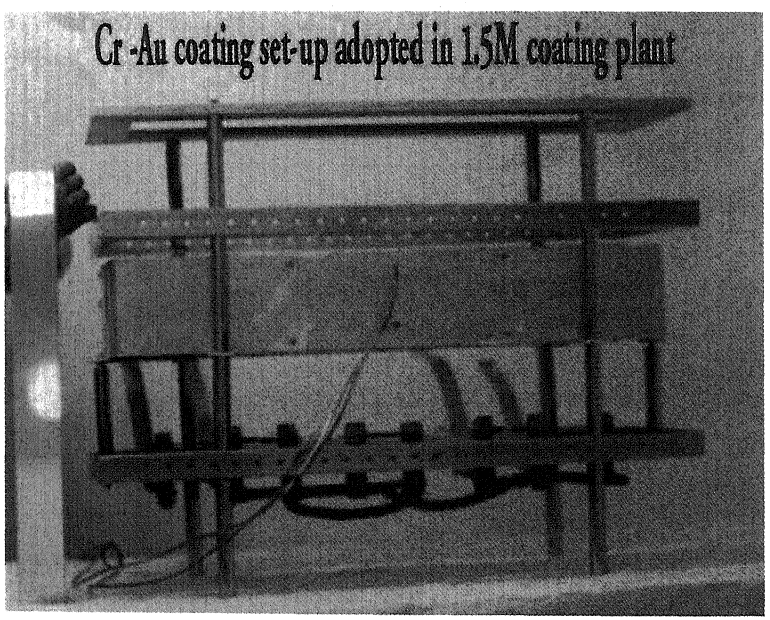
Space optics : Optical design of the UVIT payload for the ASTROSAT has been completed including configuration, field correctors, lightweighting of the mirrors and scatter light analysis. Optical system parameters can thus now be more or less frozen.

Gold coating : A setup for Cr - Au coating using 1.5m coating plant has been built and ready for use. Strip mirrors of SRBL optics can be coated using this setup (see the picture below).

2m Coating plant : A 2m vacuum coating plant for Indian Astronomical Observatory, Hanle is being setup. This assumes great significance as the plant has to be operated at extreme thermal environment (+25 to -25 degree C) at high altitude. Specifications and design details have been completed. M/s. Hind High Vacuum Co. will be fabricating the plant. The installation of the plant will be done at Hanle.

The following are the broad specifications:

a. Mirrors upto 2m diameter can be coated in this plant with surface uniformity of the order of 50 nm (± 25 nm).



b. Weight of the mirror and the ring which can be accommodated is ~ 1800 Kg.
c. Ultimate vacuum for coating < 10^{-6} torr.
d. The total duration for one cycle ~ 3 hours (i.e. total pump down time and coating operation).
e. Electron beam gun evaporation and thermal evaporation are available.

Adaptive optics : Work on wavefront sensing for adaptive optics is continuing. Algorithm for phase retrieval from a single lateral shearing interferogram has been developed. Efforts are in progress to fit the phase to estimate the surface errors in terms of polynomial coefficients.

Shack Hartmann wavefront sensor based wavefront sensor for adaptive optics was fabricated inhouse and tested. It uses a lenselet array of 69 x 69 lenses of 300 microns. A CMOS imager of 512 x 512 pixel is used to acquire the images. Reference and aberrated images are captured and Zernike coefficients are calculated.

Final testing of adaptive mirror (MEMS based 37 actuator) in closed loop configuration is being tried out. Using the mirror influence function, calculated by finite element analysis, the voltage matrix is generated, which is then applied to the actuator for a given wavefront correction.

(A.K. Sexena)

The observatories

Kodaikanal Observatory

Improvement of coarse guiding unit at Kodaikanal tunnel :

Three bins namely coarse compensation unit, relay unit and power supply unit have been develped for coarse guinding unit. Software for four channel data acquisition and stepper motor control for the PCI - 9112 Card has been developed in C.

(K.C. Thulasidharen, A.V. Ananth, Jagdev Singh)

Gauribidanur Observatory

Tracking system : In its present configuration, the Gauribidanur radioheliograph (GRH) is operated mainly as a meridian transit instrument and therefore it produces only few images of the Sun everyday. In order to exploit the full potential of the GRH, it is necessary to equip it with an electronic tracking system comprising of delay circuits operated through remotely controlled diode switches. As a preliminary step, a prototype unit was designed, fabricated and connected to a few selected antenna groups near the receiver room. Observations were carried out on several strong calibrator sources at various hour angles and declinations to check the performance of the system. The results were extremely satisfactory; the variation of amplitude, phase and the overall system gain were almost close to the expected values. Encouraged by the results, various mechanical, hardware & software jobs are presently being carried out to install a full fledged tracking system for the entire array. The completed system will be used for observations of the Sun and other sidereal sources for about 6 hrs everyday. One can understand the temporal evolution and behaviour of the transient energy releases from the Sun in a better way with such a continuous data set.

(R. Ramesh, G.A. Shanmugha Sundaram, K.R. Subramanian and M.S. Sundara Rajan)

Multi-frequency control unit : A multi-frequency control unit for carrying out observations simulataneously at different frequencies (upto a maximum of 4) in the range 30-150 MHz with the GRH was designed and fabricated. It was thoroughly checked for various static and dynamic inputs. The necessary software to modify the existing single frequency data acquisition set-up to function in synchronization with the multi-frequency control unit is currently being written. The observations will aid in understanding the spectral nature and hence the emission mechanism of various solar phenomena.

(R. Ramesh,, M.S. Sundara Rajan, K.R. Subramanian)

GPIB controlled spectrum analyser for studies of transient, energetic emission from the solar atmosphere : A new GPIB controlled spectrum analyser (operating in the frequency range 30-130 MHz) for obtaining a dynamic spectrum of the transient, energetic events in the solar atmosphere has been put into operation recently at the Gauribidanur radio observatory. Radio emission from the Sun in the above frequency band normally originates in the altitude range between 0.3 $R_\odot$ and 1.5 $R_\odot$ above the solar photosphere. Observations in this height range are of basic physical interest since the primary energy release sites of some of the transient, energetic events (like solar flares and coronal mass ejections) are situated there. Eruptive energy release disposes of a part of the excess energy into nonthermal particles. The radio burst emission in the above frequency range is a tracer of otherwise invisible nonthermal electron populations. The bursts are highly variable in frequency, time and intensity. Therefore, continuous frequency coverage with high time resolution is necessary.

(E. Ebenezer, R. Ramesh and K.R. Subramanian)

Indian Astronomical Observatory

The highlights of the year

* Publication of the first scientific paper using observations from the 2-m telescope (Cowsik et al 2001, Bull. Astr. Soc. India, **29**, 157-168).

* Dedication of the 2-m telescope to the nation, and naming it Himalayan Chandra Telescope by Prof. V.S. Ramamurthy, Secretary DST, on behalf of Dr. M.M. Joshi, Hon'ble minister for Human Resource Development, Science and Technology, Ocean Development, on 29 August 2001.

The Himalayan Chandra Telescope

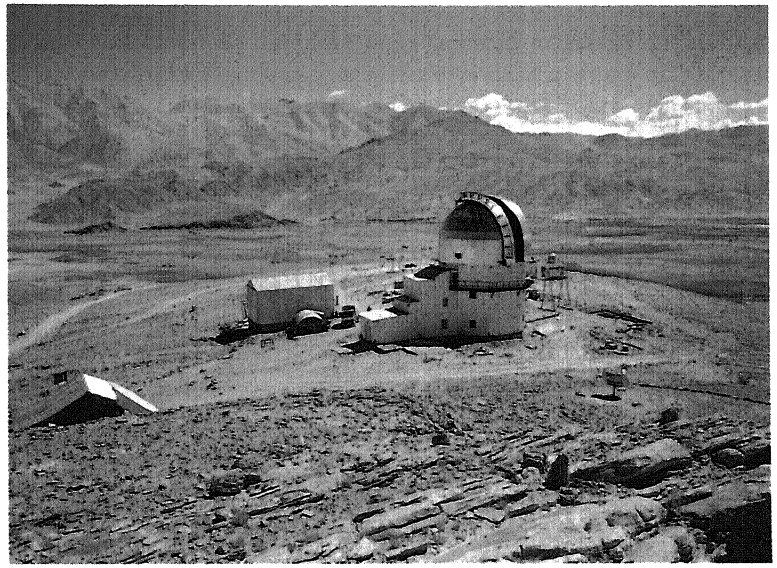
The telescope : The telescope performance through the seasonal cycle in the extreme environments continued through the year. A preventive maintenance run was undertaken in August 2001. The procedures for balancing and pointing model were studied in great detail. The tracking performance and image quality were also monitored.

The autoguider : The autoguider for the HCT is under development and tests continued through the year.

The instruments : The Himalayan Faint Object Spectrograph Camera was received at IIA, transported to Hanle and installed on the telescope in October 2001. Commissioning tests are underway and are expected to be completed early next year. The Near-infrared Camera was received at IIA in December 2001. The user interface is being developed at IIA following which the instrument will be transported to the site and installed. The commissioning is scheduled early in 2002-03. The CCD imager is being tested with a new, high-efficiency chip and is expected to be commissioned in 2002-03.

The dome : Most of the works that remained incomplete due to the onset of the winter of 2000 were completed during the summer of 2001 and the dome is operating well during the following winter. A few minor works that remain will be undertaken during the summer of 2002.

(T.P. Prabhu)



Software for the 2 m telescope : The software for the 2 m telescope is under testing for the past one year. The software developed under client/server architecture permits operation of telescope, dome, meteorogical instrument and autoguider camera in an integrated way, with a Linux based User Interface. An observatory server controls the operation of all the above mentioned facilities through the User Interface and also forms the repository of all the status and information received from various subsystems. The autoguider software has been tested for on-axis guiding. A final version of autoguider software is still

udner testing. This should permit off-axis guiding and other finer requirements needed for efficient observing. While the telescope, dome and meterological instruments can be operated remotely from Hosakote, the autoguider operations are local and forms a part of the local control loop at Hanle. It is expected that the autoguider software should become opertional shortly.

(A.V. Ananth, Anil Raut, Parihar, D.K. Sahu, Dorje Angchuk, Thashi Tsering)

Site characterisation

The automated weather station is continuing to provide data. The 220-GHz radiometer continued to operate all through the year. The results show that the atmospheric opacity at Hanle at this frequency is comparable to that of Mauna Kea, and appears still lower during the winter months.

220 GHz zenith atmospheric transparency at IAO : The 220 GHz (1.36 mm) measurements of zenith optical depth obtained to characterise the Indian Astronomical Observatory, during the period from late December 1999 to early May 2000 and early October 2000 to September 2001 have been analyzed in detail. The data were sampled at an interval of 10 minutes. The 220 GHz opacity is found, to be less than 0.06 for a significant fraction (40%) of the time during the winter months, indicating that Hanle is one of the good observing sites for submillimeter-wave astronomy. A preliminary correlation is made with the precipitable water vapour derived from surface relative humidity and air temperature measurements during the same period obtained with a weather station installed at the site. The results show that the Hanle site compares well with other high-altitude sites like Mauna Kea and Atacama desert.

(*P.G. Ananthasubramanian, *Satoshi Yamamoto and Tushar P. Prabhu)

Infrastructure

The SPV power plant supplied by M/s CEL, the diesel generator sets and the satellite communication links have been performing satisfactorily. The SPV power plant of M/s TATA BP Ltd and the Liquid Nitrogen plant have had minor breakdowns which were attended to. The permanent building of Megh Nad Saha Astronomical Archives was completed during the current year.

Centre for Research & Education in Science & Technology (CREST)

The remote control and data download facility for the Himalayan Chandra Telescope has been functioning from CREST throughout the year. Most of the major astronomical publications are available through internet subscriptions at this centre. The staff strength has been augmented recently to 4 astronomers, 1 post-doctoral fellow, and 3 engineers. The facility for physics experiments is being used for reserch in non-linear optics.

(T.P. Prabhu)

High altitude gamma-ray telescope (HAGAR)

The instruments on satellites of the last decade detected gamma-ray emission (1 MeV - 10 GeV) from two classes of astrophysical objects: radio pulsars and active galactic nuclei. While the next gamma-ray satellite GLAST which will cover the higher energies is expected to go in orbit in the next few years, the only method available for the study of these sources at present is the ground-based Atmospheric Cerenkov Technique (ACT). However, the energy threshold of ACT, which is ~ 150 GeV at present, needs to be lowered to study these sources ~ 20 GeV. While these low energies are possible in principle with very large and expensive mirrors, the alternative method is to exploit the low attenuation of cosmic rays and high transparency for the ensuing Cerenkov radiation at very high altitudes. Detailed simulations for an atmospheric Cerenkov array (with 7 telescopes of modest size) at Hanle have shown that the energy threshold can be lowered to ~ 20 GeV, with the peak of energy distribution of events at 35 GeV. Using the arrival direction, pulse height and time information, one expects a ~ 10 sigma signal with 1 hour of operation for gamma rays from a Crab-nebula-like source.

IIA and TIFR plan to build an array of 7 telescopes spread over a circle of radius 50 m in Hanle, termed as HAGAR Observatory. Each telescope will consist of seven 40-cm mirrors with individual prime-focus detectors mounted on a single mount. The design is in progress and the fabrication will commence during the next year.

(R. Cowsik, P.N. Bhat, P.R. Viswanath)

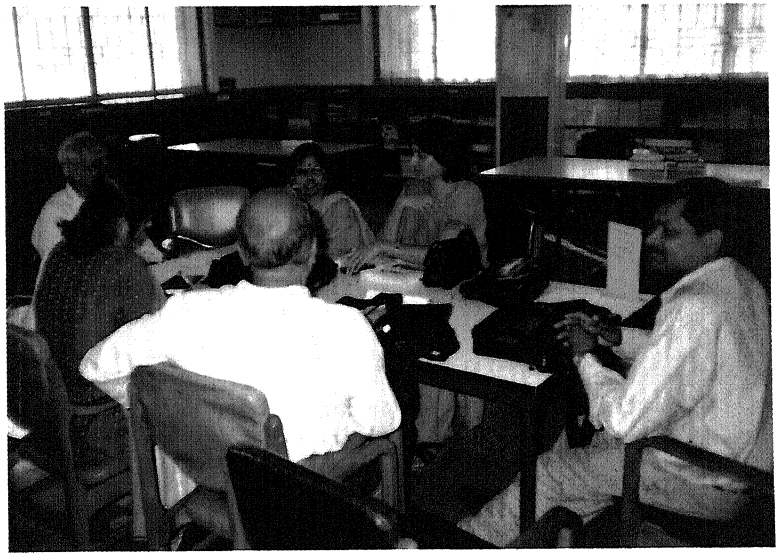
Library

407 books were added to the Institute's Library during the year. The Library continued to subscribe to 155 journals. In addition 4 new journals were included during the current year. Forty five of the above journals can also be accessed electronically. It continued to receive more than 100 observatory publications, newsletters and annual reports. More than 200 volumes of journals were stiched and bound, and 300 inter library requests were honoured. A consortia was formed between astronomy libraries for subscription to Kluwer journals. This has enabled our library to get access to additional 15 journals. The Library also entered into an agreement with Institute of Physics, UK to access 23 physics journals on line. It acquired the Linux version of Libsys software which is more versatile than the older version. The data base now can be accessed through local network. The Library also collected all the thesis published by IIA scientists during the last 50 years and a new data base has been set up for the theses.

A Vagiswari and Christina Birdie attended the Astronomical Society of India meeting held at IUCAA, Pune from 5th to 8th February 2002 where the astronomy libraries had a parallel session. A consolidated report was presented by A. Vagiswari during the "***Reports from Observatories***" session of the ASI meeting.

(A. Vagiswari)

Discussion group with A. Vagiswari and Christina Birdie present, during the FORSA meeting at IUCAA, Feb. 2002 ▼



Graduate studies programme

Board of Graduate Studies

The Institute operates a vigorous programme of graduate studies under the Board of Graduate Studies which forms a vital component of research and training at the Institute.

Selection

Candidates with a M.Sc. degree in Physics/Maths or M.Tech in Engineering or with a B.E./B.Tech degree and a strong background in physics are eligible to apply for admission to the Ph.D. programme. Entry to this programme is possible through :

• **JEST :** Students are selected after undergoing the Joint Entrance Screening Test (JEST), conducted jointly with 13 member institutes. This is widely advertised and takes places annually at several centres distributed over the country. The programme commences in August each year.

• **IIA Entrance Exam :** Students are selected after undergoing an entrance test at IIA, Bangalore followed by an interview. This programme begins each year in January.

• **JAP :** IIA is a major partner in the Joint Astronomy Programme (JAP), which is co-ordinated by the IISc. JAP has 5 member institutes. JAP students have the option to join IIA after the first year of course work.

Currently, there are 31 full time Ph.D. students working on a diverse range of problems.

Course Work

All students are required to undergo course work for 2 semesters in the first year. They are required to study four subjects per semester, consisting of core subjects and optional subjects. Furthermore, all students are also required to do a 3 month experimental/observational project at the end of the first year, which is treated as part of the course work.

Highlights of students' research work during the year

During the year the following fields were investigated :

Sun and solar system : In this area, the topics covered are : Morphological and dynamical properties of the chromosphere; Multi-frequency radio observations of the solar corona using the Gauribidanur radio-heliograph; Radio emission from the quiet sun; Missing flux problem and sunspot problems; Techniques for achieving higher spatial resolution.

Stars and stellar systems : The various topics in this area are : Studies of insterstellar medium; Star forming regions in the Galaxy; Studies of post-AGB stars and proto-planetary nebulae; Study of metal poor stars; Radio emission from pulsars; Studies of poor clusters of galaxies; studies of Seyfert galaxies; Nature of sources associated with gamma ray burst phenomenon.

Theoretical astrophysics : In this area, the students are working on temperature profiles and spectra of accretion disks around rotating neutron stars; black holes in non-flat backgrounds.

Physics : The topics in the subject that are being pursued are atomic and molecular many-body processes in astrophysics; Relativistic many-body studies of parity non-conservation in heavy atomic ions; Experimental studies in acousto-optics; Measurement of the Casimir-Polder force at sub-micron distance scales using an atomic beam; Torsion balance investigation of the Casimir effect.

Award of Ph.Ds

J. Javaraiah was awarded the Ph.D. degree by the Bangalore University for his thesis titled "Study of Sun's rotation and solar activity", under the the supervision of M.H. Gokhle.

M. Srinivasa Rao was awarded the Ph.D. degree by the Bangalore University for his thesis titled "Atmospheres of the components of close binary stars", under the supervision of A. Peraiah.

B.A. Varghese was awarded the Ph.D. degree by the Bangalore University for his thesis titled "Application of radiative transfer equations to scattering problems" under the supervision of A. Peraiah.

Subhabrata Majumdar was awarded the Ph.D. degree by IISc for his thesis titled "Probing the universe with Sunyaer-Zelderiah Effect", under the supervision of Pijush Bhattacharjee.

Sanjoy Majumdar was awarded the Ph.D. degree by the Bangalore University for his thesis titled "Study of atomic and molecular many-body processes in astrophysics", under the supervision of B.P. Das.

Pavan Chakraborty was awarded the Ph.D. degree by the Bangalore University for his thesis titled "Investigation of Dust from selected comets", under the supervision of R. Vasundhara.

Sudip Bhattacharyya was awarded the Ph.D. degree by IISc. for his thesis titled "Temperature profiles and spectra of accretion disks around rapidly rotating neutron stars", under the supervision of Pijush Bhattacharjee.

Faculty Improvement Programme

Under this programme teachers employed in colleges or universities are given an opportunity to carry out research work at the Institute under the supervision of one of the staff members towards a Ph.D. degree. Presently, there are 2 students under this programme.

In addition, staff members at IIA can also register for the Ph.D. degree under the supervision of one of the staff members.

Students' training programme

As a part of our outreach programme, the Institute conducts various student training programmes. Under this programme, students entering their final year of M.Sc./ B.E. work on short term projects with supervisors at IIA during the summer for about 6 weeks. During 2001-02, 8 students participated in this programme.

In addition to the Summer Programme, a longer term training programme lasting 6 months is also conducted.

Post-doctoral programme

The Institute has an ongoing Post-doctoral Programme, in which scientists with Ph.Ds can apply. Currently there are 6 PDFs at the Institute.

JEST 2002

The Institute was the coordinating institution for the JEST 2002. Over 4000 applications were received from all over and processed. About 3200 candidates took the test conducted at 25 centres on 17th Feb. 2002. The JEST Committee at IIA successfully oversaw the advertisement, application processing, preparation of question papers, evaluation and distribution of results to the member institute and the candidates. The novel aspect of this year's JEST was computerized processing of the application forms; web access was enabled for application form as well as the results. As a consequence of this, the results could be announced early.

(S.S. Hasan)

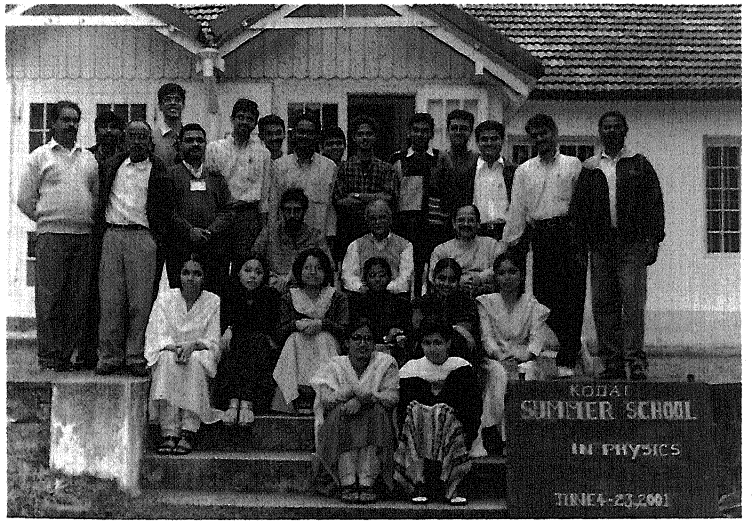
Conference reports

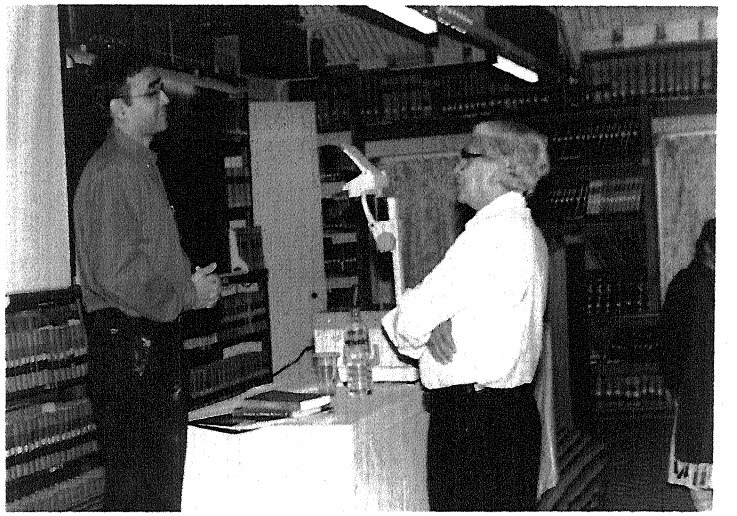
Kodaikanal Summer School in physics

A summer school in physics comprising of courses on quantum mechanics, statistical mechanics and nonlinear dynamics was conducted at the Indian Institute of Astrophysics, Kodaikanal during June 04 - 23, 2001. Eighteen final year M.Sc., and B.Sc., physics students on an all - India basis were selected to participate in the course. Lectures and tutorials were taken by Professors Vasant Natarajan, Ajay Vasan, I.I.Sc., Bangalore; Neelima Gupte, T.M. Janaki, I.I.T.M., Chennai; A. Abbas Rangwala, University of Mumbai, Mumbai; Anil Gangal, Asutosh Sharma, University of Pune, Pune; N.D. Hari Dass, Sukratu Barve, Institute of Mathematical Sciences, Chennai.

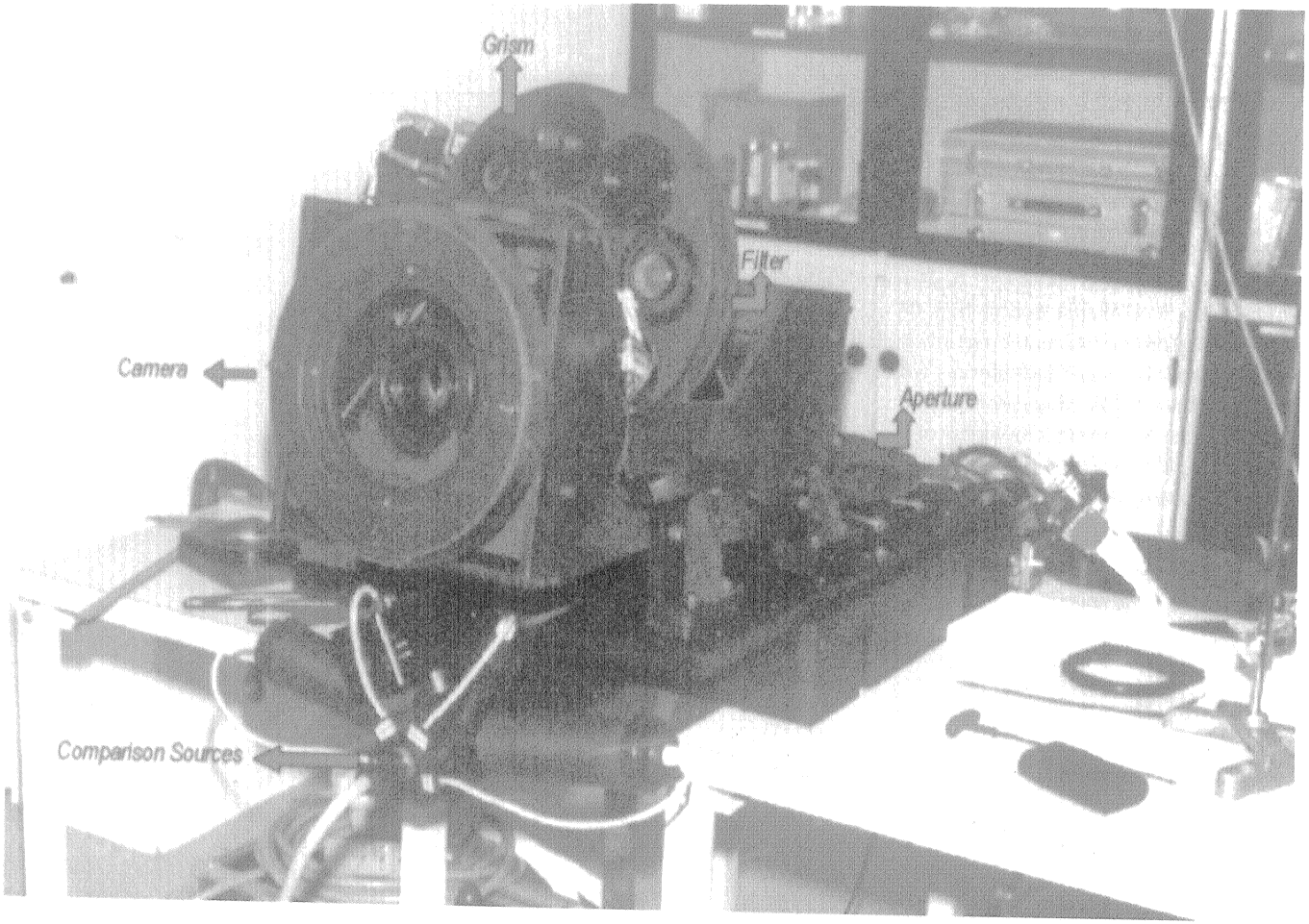
(S.S. Gupta)

Participants of the Kodaikanal Summer School in Physics, June 2001, at the Kodaikanal Observatory ▼





▲ Prof. V.K. Gaur (right) in a discussion with Prof. Vasant Natarajan, Kodaikanal Summer School in Physics, June 2001



Himalayan Faint Object Spectrograph & Camera (HFOSC).

Miscellaneous

Collaborative activities with other institutions

Major collaborative activities continued, or were started with the following Institutes :

University of Calicut, Since March 1999 : mutual cooperation in the common interests of teaching and research in astronomy and related subjects.

Copenhagen University Astronomical Observatory, Denmark, Since April 1999 : Collaboration in the fields of galactic and extragalactic astronomy, and as a specific step towards building and utilization of a low dispersion spectrograph called "Hanle Faint Object Spectrograph & Camera" (HFOSC).

McDonnel Center for Space Sciences, Washington University, St Louis, USA, Since June 1999, to collaborate in the field of astronomical transient phenomena, as specific step towards cooperation on the installation and utilization of two 50-cm aperture telescopes forming the Antipodal Transient Observatory.

ISRO-Satellite Centre, Bangalore : Optical polishing of the sun shield panels of the INSAT-3D space imager and sounder has been continuing at the Photonics Division laboratory.

Observational Programmes with I-STEP : The STP group participated in the Sporadic-E (Es) Campaign held in Summer 2000 under I-STEP. Regular data acquisition in the monitoring mode continued with the experimental facilities in Kodaikanal Observatory (IPS42 ionosonde, HF Doppler Radar and magnetometer).

Centre for Mathematical Modelling and Computer Simulation (C-MMACS), Bangalore: 'Inverse modeling of broadband seismograms to determine the shear velocity structure beneath some geodynamically significant parts of the Indian continent'.

Laboratoire des Science du Climat et de L'Environment (LSCE), CEA, Saclay - Orme des Merisiers - France: 'Monitoring of carbon and green house gases concentration at Hanle, and inverse modelling of global fluxes'.

Collaboration in teaching

IIA is an active partner in the Joint Astronomy Programme (JAP) at IISc since its inception in 1982. 15 students from this programme have pursued their doctoral work under the supervision of scientists from IIA.

Scientists from IIA have been regularly participating in teaching programmes at other institutes also such as Bangalore University and Osmania University etc.

Astronomical Society of India

A major part of the activities of the Astronomical Society of India continued to be centred at the Institute. A.K. Pati has been the Secretary of the ASI since November 2000. Harish Bhatt took over as the editor of the Bulletin, ASI in early 2001 from Vinod Krishan. D.C.V. Mallik is the Chairman of the Scientific Organizing Committee for ASI meetings for a period of three years.

The Executive Council of the ASI has placed on record its appreciation of the support given by IIA to the editorial and publication activities of the Bulletin ASI for almost two decades.

The 21st Meeting of the ASI was held at IUCAA, Pune in February 2002. A large part of the organisational work relating to the scientific program as well as society matters was done from IIA.

Couroupita guianensis (Nagalingam), IIA, Bangalore Campus

Personnel

Academic / Scientific / Technical Staff as on 31.3.2002 includes the following :

Director: Ramanath Cowsik

Senior Professor: Vinod Krishan, N.Kameswara Rao, J.H.Sastri, R.Srinivasan

Professor: B.P.Das, S.S.Hasan, R.C. Kapoor, D.C.V.Mallik, M.Parthasarathy, T.P.Prabhu, Ram Sagar *(on lien to SO, NainiTal)*, Jagdev Singh, C.Sivaram

Head Photonics: A.K.Saxena

Sr.Principal Scientific Officer: A.V.Ananth

Scientist E: G.S.D.Babu, S.P.Bagare, H.C.Bhatt, A.K.Pati, R.Rajamohan, A.V.Raveendran

Librarian: A.Vagiswari

Associate Professor II: Jayant Murthy

Associate Professor : Sunetra Giridhar

Scientist D: P.Bhattacharjee, S.Chatterjee, P.K.Das, S.S.Gupta, S.G.V.Mallik, S.Mohin, K.N.Nagendra, P.M.S. Namboodiri, K.E.Rangarajan, S.K.Saha, K.R.Subramanian, R.Surendiranath, R.Vasundhara, G.C. Anupama, M.V. Mekkaden

Sr.Research Scientist: B.Raghavendra Prasad

Principal Scientific Officer: V.Chinnappan

Engineer E: M.S. Sundararajan, B.R.M. Rao

Engineer D: G.Srinivasulu

Engineer C: S.S. Chandramouli, Faseehana Saleem, J.S. Nathan

Scientist C: B.C.Bhatt, R.K.Chaudhuri, A. Goswami, R.Kariyappa, J. Javaraiah, Prajval Shastri, K.P.Raju, K.B.Ramesh, A.Satyanarayanan, R. Ramesh, S.K. Sengupta M. Srinivasa Rao

Sr.Engineer (Civil Works & Estates): N.Selvavinayagam

Scientific Officer SD: J.P.L.C.Thangadurai

Engineer (Electronics & Computer Science) : A.N.Raut

Engineer (Mechanical): P.M.M.Kemkar

Engineer (Civil): R.Ramachandra Reddy

Research Scientist: R.T.Gangadhara, Arun Mangalam.

Scientist : K.M.Hiremath

Asst.Librarian C: Christina Birdie

Scientific Officer SC: P.S.M.Aleem, J.V.S.Vishveswara Rao, B.A.Varghese, L.Yeswanth,

Scientist B: B.S.Nagabhushana, D.K. Sahu, A.Subramanian, K.Sundararaman

Technical Officer: M.Mohd.Abbas, N.Jayavel, P.K.Mahesh, S.Muthukrishnan, B.Nagaraja Naidu, R.Muraleedharan Nair, K.G. Unnikrishnan Nair, J.P.A.Samson

Engineer B: Dorje Angchuk, K.Padmanabhan, K.C. Thulasidharan

Documentation Officer: S.Rajiva

Engineer SC: M.P.Singh

Tech. Associate B: A. Selvaraj, N. Sivaraj

Research Associate: K.Jayakumar, K.Kuppuswamy, M.J.Rosario

Technical Associate: P. Anbazhagan, E.E. Chellasamy, Tsewang Dorjai, F. Gabriel, P.U. Kamath, A.V. Velayuthan Kutty, G.N. Rajasekhara, K. Rangaswamy, R. Selvendran, K.S. Subramanian, G.S. Suryanarayana

STA B: C. Nanje Gowda

Distinguished Professor: Vinod K.Gaur, K.R. Sivaraman

Adjunct Scientist: N. Krishnan, C.S. Unnikrishnan

Visiting Sr.Professor: M.H. Gokhale, C.V. Vishveshwara, G. Ramachandran

UGC Emeritus Fellow: N. Sankaran

Visiting Fellow/PDF: U.S. Kamath, S.K. Muneer, P.S. Parihar, Hasi Ray, S. Sriram, Kiran Jain, Pavan Chakraborty

SRF: S. Ambika, S.G. Bhargavi, S. Bhattacharyya, G. Gauba, K.P. Geetha, M. Gopinath, C.Kathiravan, P. Kharb, D.V. Lal, K.V.P. Latha, S. Majumdar, Sonjoy Majumder, P. Manoj, Rajalakshmi, B.S. Ramachandra, Mangala Sharma, B.K. Sahoo, D. Suresh

JRF: Ankur Chaudhari, J. Baliga, R.K. Banyal, K. Nagaraj, M.K. Nayak, M.S. Rahaman, P. Shalima, G.A.S. Sundaram, R.M.C. Thomas, Vijay Shankar

Faculty Improvement Programme : R. Angiraz, Paniveni U. Shankar

APPENDIXES

APPENDIX A

Publications

In Journals

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APPENDIX B

Attendance / participation in Meetings, Workshops, Seminars and Lectures

The XXI ASI Meeting at IUCAA, Pune, 5-8 February, 2002 was attended by several participants from the Institute. The papers presented will be published in the ASI proceedings in BASI (vide appendix A) They also participated in the deliberations of the Decadal Vision Document for Astronomy and Astrophysics commissioned by the Indian Academy of Sciences, in the (a) Optical/IR/UV Astronomy, (b) radio astronomy and (c) X-ray astronomy panels.

P. Bhattacharjee attended the WHEPP-7 Workshop at HRI, Allahabad (January 4-15, 2002) as a member of the NOC. He gave an invited talk on 'Sources of Ultrahigh Energy Neutrinos'. He also gave an invited talk on The Mystery of the Cosmic Ray Events above 10^{20}eV: Physics & Astrophysics of the Origin of Extreme Energy Cosmic Rays.

Hasi Ray attended the International Workshop on "Low Energy Positron and Positronium Physics" organised by Los Alamos Laboratory, Santa Fe, New Mexico, USA held on July 25-27, 2001. She also attended the International Conference on "Current Developments in Atomic, Molecular & Chemical Physics with Applications" CDAMCP held at the Department of Physics & Astrophysics, University of Delhi on March 20-22, 2002.

S.S. Hasan attended the following meetings: American Geophysical Union, Boston (U.S.A.), May 31 - June 4, 2001; Silver Jubilee Meeting of the USO, Udaipur, October 16-19, 2001.

J. Javaraiah attended the International workshop, "Probing the Sun with High Resolution", October 16 - 19, 2001, Udaipur, India and gave an oral presentation entitled, 'Difference between solar differential rotation during 'even' and 'odd' numbered solar cycles'. J. Javaraiah attended the 21st International National Solar Observatory /Sacramento Peak Workshop, 'Current Theoretical Models and Future High resolution Solar Observations: Preparing for ATST', March 11 - 15, 2002, Sunspot, New Mexico, U.S.A. and gave a presentation entitled 'Relationship Between Magnetic Structure of Small and Large Sunspot Groups'. During March 16 - 21, 2002, he worked at Sunspot, with Dr. R. W. Komm (NSO, Tucson) on an ongoing collaborative research programme on short-term periodicities in the solar surface rotation.

R.C. Kapoor attended the 16th NIAS course for senior executives on 'Managing India's Diversity' 7-19 January 2002 at National Institute of Advanced Studies, IISc, Bangalore.

R. Kariyappa attended the International Solar Cycle Studies (ISCS) - 2001, Longmont, CO, USA, June 13 - 16, 2001. He also attended the SCOSTEP/ CEDAR Workshop - 2001, Longmont, CO, USA, June 17 - 22, 2001.

A. Mangalam gave four lectures at "Cosmology and Large Scale Structure", a school held at HRI, Allahabad, December 13-31, 2001.

P.M.S.Namboodiri attended the IAU Symposium 208 - Astrophysical Supercomputing Using Particle Simulations - during 10 - 13 July, 2001 at University of Tokyo, Tokyo, Japan and made a presentation titled 'Relaxation time in spherical galaxy simulations'.

J. H. Sastri participated in the workshop on "Role of ionospheric scintillation and total electron content in space weather research", held in Andhra University during November 20-21, 2001. He also participated in the XII National Space Science Symposium (NSSS-2002) held in Bhopal, during February 25-28, 2002.

A.K.Saxena attended a seminar on " Perspectives in Modern Optics, Photonics and Optical Instrumentation" in January 2002 and presented a paper on "Long Trace Profilometer for precision profile measurement of Synchrotron Beam Line Optics".

On the occasion of 60th birth anniversary of Prof.Kehar Singh, **Dr.A.K.Saxena** has contributed a review article titled, "Testing of Large Optical Surfaces" for the book presented to Prof.Kehar Singh.

S. Sengupta attended the International Conference on Multicolour Universe held at TIFR, Mumbai, September 11-14, 2001 and presented a paper titled Modeling the Atmosphere of the Coolest White Dwarf WD0346+246. He also visited IUCAA and gave a talk on 'Atmosphere of Brown Dwarfs and Extra-solar Planets'.

Invited talks

S.P. Bagare gave an invited talk on 'The Physics of Solar Atmosphere' in IUCAA - organized workshop on Astronomy & Astrophysics at the Department of Physics, VR College, Nellore, during September 2001.

H.C. Bhatt gave a Rapporteur Talk on contributed papers on "Stars and The Galaxy" at the XXI ASI Meeting, IUCAA, Pune (5-8 February, 2002)

P. Bhattacharjee gave an invited talk on 'The Highest Energy Frontier: Physics and Astrophysics of Extreme Energy Cosmic Rays', Kodaikanal Summer School, June 2001, and a talk on 'The Mystery of the Cosmic Ray Events above 10^{20}eV: Physics. & Astrophysics of the Origin of Extreme Energy Cosmic Rays" at the 21st ASI meeting, 5—8 February, 2002. He also gave a talk on 'Sources of Ultrahigh Energy Neutrinos' at the — Working Group seminar in the Neutrino & Astroparticle Physics (NAP) Working Group, WHEPP-7 meeting, HRI, Allahabad, 4—15 January 2002; and 'Astrophysical Sources of Ultrahigh Energy Neutrinos', at CTS, IISc, Bangalore, 17 May 2001.

R. Cowsik gave a number of invited talk as follows : 27-4-2001 Dark Matter in the Universe, in the Discussion Meeting in IIA. 4-7-2001 Dark matter and the Dynamics of the Galactic Halo, Colloquium in TIFR, Mumbai. 30-8-2001 Perspectives on Indian Astronomy, CREST/IAO Dedication seminar. 11-9-2001 Hanle - An extraordinary site for astronomy, international Symposium on Multi Colour Universe, TIFR, Mumbai. 24-10-2001 'DM and the dynamics of the Galactic Halo', Physics Colloquium, University of New Hampshire, Durham, USA. 19-11-2001 Beauty of astronomy through the eyes of a physicist, Jawaharlal Nehru Memorial Lecture, Jawaharlal Nehru Planetarium, Allahabad. 30-11-2001 The Ultimate Step in the Copernican Revolution - an overview of the new cosmology, 63rd Acharya J.C. Bose Memorial Lecture Bose Institute, Kolkata. 7-12-2001 Lecture at 3rd Annual Course 'Challenges and Opportunities for the Indian Space Enterprise', NIAS, Bangalore. 22-12-2001 Valedictory address: Reflections on Einstein's Spirituality International Symp on Science and Religion, National College, Bangalore. 21-02-2002 The extent of the dark matter halo (with C. Ratnam, P. Bhattacharjee & S. Majumder) 5th International UCLA Symposium on Sources and Detection of Dark Matter and Dark Energy in the Universe, Feb 20 - 22, 02 Marina del Rey, CA, USA. 09-03-2002 The progressive decline of anthropocentricism in cosmology, Jawaharlal Nehru Birth Centenary Lecture of the Indian National Science Academy, New Delhi.

B.P. Das gave an invited talk on "Testing the Unification of Fundamental Forces Using Laser Cooling and Trapping" Institute of Physics, Bhubaneswar, Jan, 2002; "The Nuclear Anapole Moment" at the Bhabha Atomic Research Centre, Mumbai, May 2002.

S.S. Hasan gave an invited talk on Dynamics and Heating of the Solar Chromosphere, Silver Jubilee Meeting of the Udaipur Solar Observatory, October 16-19, 2001; A Decadal Vision Document for Solar Physics in India, at the ASI meeting in Pune, 2002.

K. N. Nagendra was invited to deliver a keynote address at the International Conference on "Stellar Atmospheric Modeling", held in Tuebingen, Germany, during April 8-12, 2002 and gave a talk on "Methods in polarized line transfer problems".

Raghavendra Prasad .B gave an invited talk on Bacteriorhodopsin-based optical 3D memories, India-Japan Workshop on Advanced Materials in Molecular Electronics (NAMME), Dec. 10-11, 2001, National Physical Laboratory, Delhi.

Ravinder Kumar Banyal and Raghavendra Prasad .B were invited to gave a talk on "Intensity-dependent absorption and temporal properties of two-wave

mixing in photorefractive $BaTiO_3$ crystals", India-Japan Workshop on New Advanced Materials in Molecular Electronics (NAMME-2001), 10-11 December 2001, National Physical Laboratory, New Delhi.

J. H. Sastri gave an invited talk on ' Storm-time equatorial ionosphere-thermosphere system (EITS) at the XII National Space Science Symposium (NSSS-2002) held in Bhopal, during February 25-28, 2002.

C. Sivaram was invited to give a 'Thursday colloquium' at Raman Research Institute (6 Dec 2001) on "Gravity on Large and Small Scales" and "Century of Nobel Prizes" (10 Dec. 2001), GRIM lecture on 'Hawking radiation' (17 July 2001).

ArXiv

G.Ramachandran and P.N.Deepak : Radiative capture of neutrons by protons.
arXiv: nucl-th/0203080 v1 29 March 2002.

C. Sivaram (with L. Garcia de Andrade): Gravity effects on charged - particle and neutron interferometers.
arXiv: gr-qc/0111009 VI, 04 Nov.2001 (Grav.letts.).

C.Sivaram (with G.Sudhakaran): Source terms in the Einstein equations.
arXiv: gr - qc/0106029 VI, June 2001.

Visits

S.Giridhar visited Institute of Astronomy at National Univ. of Mexico, Mexico city during Nov 7 to Dec 8, 2001 to work with Prof. Arellano Ferro on a collaborative project. She was invited to review the Ph.D thesis synopsis of Mr. Antonio Piceno at INAOE, Puebla, (Mexico) on Dec 1, 2001. She also visited Dept. of Astronomy at Univ. of Texas at Austin, Austin during Oct 19 to Nov 6, 2001 to work with Prof.D.L.Lambert on a collaborative project.

S.S. Hasan visited the Max Planck Institute for Aeronomy in Lindau, Germany (May 2001), Max Planck Institute for Astrophysics, Heidelberg, Germany (May 2001) and the Harvard-Smithsonian Centre for Astrophysics, Cambridge, U.S.A. (May-June 2001).

R. Kariyappa visited NASA's GSFC, Huntsville, AL. USA during June 23-26, 2001 and gave a seminar on "CaII K Imaging to Understand the UV Irradiance Variability".

K.N. Nagendra visited Observatoire de Nice, France, for three months during July-September, 2001, to continue ongoing collaborations on problems of polarized line transfer theory with French and Swiss scientists.

A.K.Saxena had visited the Dominion Astrophysical Observatory, Herzberg Institute of Astrophysics, National Research Council of Canada, British Columbia, from 28th September to 7th October 2001. He had interactions with Dr.Christopher Morbey and Dr.J.B.Hutchings with regard to the design of the baffle for UVIT telescope and stray light calculations.

C.V. Vishveshwara visited ISSA, Trieste, Italy, June 2001 and the Inter University Centre for Astronomy and Astrophysics, (IUCAA) Pune, January 2002.

C.V. Vishveshwara gave a technical talk titled `Schwarzschild black hole in the Einstein Universe', SISSA, Trieste, Italy, June 2001.

Teaching / Guidance activities

S.P. Bagare is a Member, Board of PG exams in Physics, Bangalore University, Bangalore,2001-2002. He is also an external examiner in Astrophysics and Spectroscopy, BUB, 2001-2002.

P. Bhattacharjee gave a core course on High Energy Astrophysics and Astroparticle Physics, under the Joint Astronomy Program (JAP), January 2002 — April 2002.

R.T. Gangadhara guided Mr. Raguram, (M.Sc. student from Christ college, Bangalore) for his project on the "Detection of new emission components in pulsar profiles", and he also taught a course on Plasma Physics for the final M.Sc. students at the Dept. of Physics, Bangalore University from January to March 2001. He also taught a full course of Radiative Processes in Astrophysics, for Graduate School students at IIA/JAP, from August to December 2001. He guided Mr. Reji Mathew Thomas, for his project on "Jitter Imaging Data Reduction" during Sep. 2001.

S. Giridhar guided a summer school student K. Alkendra Singh for his project on "Stellar Parameterization of VBT survey stars" during May -June 2001. Giridhar gave 3 lectures on "Stellar Spectroscopy and its application" for JAP and IIA graduate students. Giridhar participated in comprehensive examination of a JAP student, Vikram Rana, conducted in October 2001.

R.C. Kapoor was external examiner of Mr. Sajad Masood for his PhD thesis work entitled: 'Two Particle Corelation Function for Multi-component System and Gravitational Galaxy Clustering' and took his viva voce exam in July, 2001, at the Dept. of Physics, Kashmir University, Srinagar.

A. Mangalam taught Fluids and Plasma Physics, a JAP course for the Fall semester, 2001.

P.M.S. Namboodiri was an examiner for M.Sc. Astronomy examination of Osmania University Hyderabad.

B. Raghavendra Prasad taught a graduate course in Experimental Physics and guided a graduate student Ms. Vaishali Kowsik on interface electronics for the Fiber-linked Echelle Spectrograph.

He also guided a summer Project student Mr. Manasendra Dutta from IIT, Kharagpur on a project entitled " Some Fundamental Properties of Photorefractive Crystals" during summer 2001.

P. Shastri supervised the Ph.D. thesis of Dharam Vir Lal, under the Joint Astronomy Programme with the Indian Institute of Science. Thesis title: Seyfert Galaxies: Nuclear Radio Structure and Unification.

C. Sivaram gave a one semester course, Jan 2002 - April 2002, on General Relativity and Cosmology to the Ph.D. students of IIA, JAP, IISC, CTS and RRI (12 students credited the course). Assignments, tests and seminars were conducted. A twenty lecture course on Gravitation, Cosmology and Gravitation were given to M.Sc and Ph.D students of Bangalore University under external faculty programme, (Jan - March 2002). C. Sivaram also gave several lectures at various refresher courses at advanced level at Calicut university (Oct. 2001), Mysore University (March 2002), Christ College, Birla Institute, IUCAA programmes, and various other summer schools.

K.N. Nagendra taught as 'Guest Faculty', Quantum Mechanics and Spectroscopy for M Sc students, at the Physics Dept.,Bangalore University. Nagendra is serving as a Co-Guide for Ms. Yee Yee Oo, of Mandalay University, Myanmar. K.N. Nagendra guided an M.Sc. Student under the VSRTP-Program organized by the BGS, and the project was titled ``Analytical and Numerical Methods of Solving the Polarized Zeeman Line Formation Problems". He also guided a M.Sc. Student under the SPSP-Program organized by the BGS, and the project was titled "Sources of Opacities in Astrophysical Plasmas". One B.Sc. Student who was recommended by Nehru Planetarium was also guided. The Project Title was "Spectral Line Broadening in Astrophysical Plasmas".

Major Organizational Efforts

JEST 2002 : Under the Chairmanship of Prof Hasan, this year, IIA co-ordinated the entire conduct of the All India test on behalf of the 13 participating institutions. These activities spanned the period August 2001 to Feb 2002. The organizing committee consisted of S.S.Hasan (chairman), S.P.Bagare, G.C.Anupama, Arun Mangalam, & Jayant Murthy.

K.N. Nagendra is serving as a Core member of the 'Scientific Organising Committee' (SOC) formed to organise the International Conference "Solar Polarisation - 3", Tenerife, Spain, Sept 30-Oct 4, 2002.

Involvement with Scientific Community

S.Giridhar served as principal investigator of an Indo-Max collaborative research project on 'Studies in Stellar atmospheres' with IIA and UNAM, Mexico as participating institutions.

J. H. Sastri served as Member of the Scientific Advisory Committee of Space Physics Laboratory (SPL) of VSSC (ISRO), Trivandrum.

H.C.Bhatt served as editor, Bulletin of Astronomical Society of India. He also served as a member in the GMRT Time Allocation Committee.

B. Raghavendra Prasad was invited by Indian Institute of Science, Bangalore, to evaluate and conduct oral examination for the following theses. "Analysis of Solar Pumped Chemical Oxygen Laser" from Department of Aerospace Engineering. Oral examination was held on 08-05-2001 and "Novel Integrated Optical Directional Coupler Array Architectures for Optical Computing and Signal Processing" from Department of Electrical and Communication Engineering. Oral examination was held on 28-05-2001.

C.V. Vishveshwara is on the Advisory Committee, of the "International Conference on the History of General Relativity," Amsterdam, July 2001. He is also on the Scientific Organising Committee, International Workshop on Mach's Principle and Origin of Inertia, IIT, Kharagpur, February 2002.

Honours

R.C. Kapoor was elected Associate, National Institute of Advanced Studies (NIAS), Bangalore in Jan 2002.

Positions/Fellowships

S.S. Hasan, Smithsonian Fellowship of the Smithsonian Institution (Washington D.C., U.S.A.) for research at the Harvard Smithsonian Centre during 2001.

Vinod Krishan, Visiting Professorship at I.N.P.E., Sao Jose, Sao Paolo, Brazil, from August 2001 to August 2002. Her senoir associateship at ICTP, Trieste has been extended upto 2007.

International Programmes

A three year Indo-French programme on "Dynamics of Solar and Stellar interiors: Seismology and Activity" commenced from September 1, 2001. On the Indian side, the participating institutions are IIA and TIFR, whereas on the French side they are observatories at Paris, Nice and Côte d'Azur. S.S. Hasan is the Indian Principal Investigator.

The DST International Long-Term Programme for Indo-Russian Co-operation in Science & Technology, is entitled, Seyfert galaxies and unified schemes, The participants are P. Shastri and D. Gabuzda.

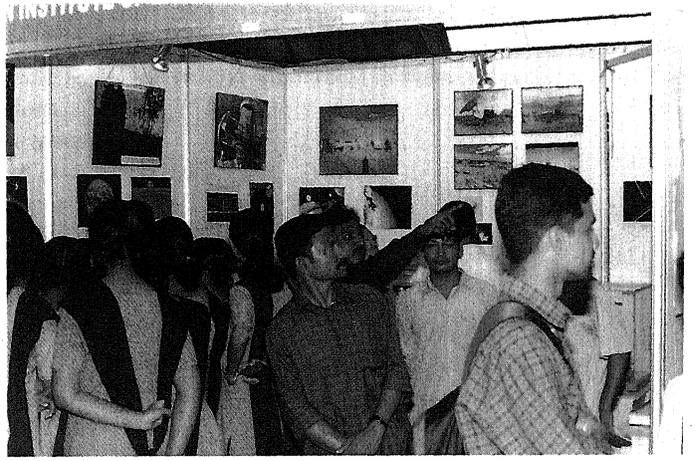
Public outreach programme

For the public outreach programme of IIA, C. Sivaram has written a hundred page article on "Astrobiology" which was put on the Institute's web page. Some publishers have evinced interest in bringing out the material in book form.

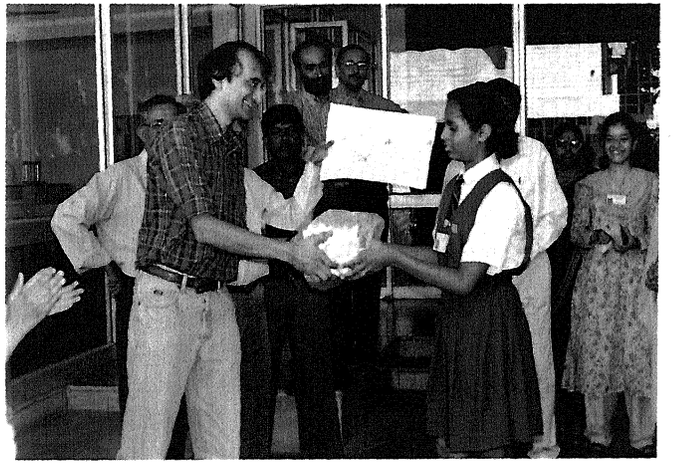
R.C. Kapoor has brought out a 28 pages colourful booklet on the IIA to mark the namakarana and dedication ceremony of the Himalayan Chandra Telescope, 29 Aug. 2001, titled 'Reaching for the Stars: From Nungambakkam to Hanle'.

Non-Technical talks

C.V. Vishveshwara gave a non-technical talk titled 'The Wisdom of Albert Einstein' Bangalore Science Forum, National College, Bangalore - July 2001 and talks titled 'The Architecture of Nature', IUCAA, Pune - January 2002 and 'Life Beyond Earth' at CAIR, Bangalore - February 2002.



▲Visitors at the stall of the Institute at the Swadeshi Vijnana Mela, 12-19 Jan, 2002, Kochi.



▲National Science Day, Feb. 28, 2002 ; Prof. Jayant Murthy gives away award to a school student.

Popular talks

S.P. Bagare gave a talk 'On the emerging picture of a dynamic Sun', Vijaya College, Bangalore, Dec 2001.

P. Bhattacharjee gave a talk titled 'The Early Universe', BASE, Nehru Planetarium, Bangalore, June 2001.

R. Cowsik participated in the Vigyan Bharathi Kannada programme of All India Radio, Bangalore alongwith **S.P.Bagare**, October 2001.

R.C. Kapoor gave a radio talk 'How old is the universe ?', All India Radio, June 3, 2001

C. Sivaram gave a talk titled 'Interstellar Flight' at the Bangalore Science Forum.

Exhibition

R. C. Kapoor organized the participation of the Institute in the second Swadeshi Vigyan Mela at Kochi, Jan 12-19, 2002 : The aim of the Mela was to convey the indigenous developments in science and industry to the common public. Several prestigious scientific and industrial organizations participated in the event. The Institute put up a beautiful stall along with other organizations under the DST. The displays showed the organization of the Institute, the campuses at Kodaikanal, Gauribidanur and Hosakote, important achievements and several interesting astrophysical phenomena. These included a model depicting the evolution of astronomical observations in the last millenium from temples to modern telescopes in India. There were also on display the model of the 2.34 m Vainu Bappu Telescope (Kavalur) and the new technology Himalayan Chandra Telescope (IAO, Hanle). A working model of a CCD along with a dewar was also put up. Kapoor also organized at Hosakote the filming of a video film 'J and K Scientific Institutions' for the Government of J&K.

National Science Day

The Institute celebrated the National Science Day this year with great enthusiasm. Six schools from the locality sent their students groups to our Institute (Seema School, Reddy School, Bethany, Bethal Academy, B. Mona, and the Madiwala Corporation School). The students were bright and alert, particularly enjoying the quiz run by Mangala Sharma and several of the students. Also gaining praise were Mr. Lancelot's optics demonstration, always a crowd pleaser, and the Zero Lab demonstrations by Suresh, Ravinder, and Rajalakshmi. Mr. P. K. Mahesh and J. Baliga arranged for telescope viewing at night which was also well received and Mr. P. U. Kamath explained the basics of the VBT and IAO. The speakers included A. Mangalam, K. N. Nagendra, R. T. Gangadhara, B. P. Das and G. C. Anupama. Virtually all of the students were involved in the quiz or in leading the high school students through or in various presentations.

(Jayant Murthy)

Educational and Community activities

P. Bhattacharjee served as a member of the National Organizing Committee (NOC) of the Seventh Workshop on High Energy Physics Phenomenology (WHEPP-7) held in Harish Chandra Research Institute, Allahabad in January 2002. He also served as a member of the Working Group on "Neutrino \& Astroparticle Physics" in the Workshop.

C.V. Vishweshwara, in the capacity of the Vice-Chairman of the, Bangalore Association for Science Education (BASE) and Honorary Director of the Jawaharlal Nehru Planetarium, has arranged a number of science workshops for students at all levels, for teachers and for disabled children. He has supervised the setting up of exhibitions called 'Science in Action'. He has supervised the production of the Planetarium programmes aimed particularly at students.

Colloquia and talks given by visitors

Empirical Approach to Pion Production in Polarized Nucleon-Nucleon Collisions
G.Ramachandran
Dept.of Studies in Physics
University of Mysore
Mysore
08 May 2001

Terahertz Site Testing in Northern Chile Using A Fourier Transform Spectrometer
Raymond Blundell
Smithsonian Astrophysical Observatory, USA
11 May 2001

Voids and Phases in Complex Plasmas
K.Avinash
Institute for Plasma Research
Gandhi Nagar
24 May 2001

Deep Inelastic Parton Distriutions in a Nucleon on the Basis of a Relativistic Independent Quark Model
N.Barik
Dept.of Physics, Utkal University
04 June 2001

Initial Speeds of Coronal Mass Ejections and their relationship to Geomagnetic Storms
P.Venkatakrishnan
Udaipur Solar Observatory
06 June 2001

Temporal Variations in Solar Structure and Dynamics
H.M.Antia
Tata Institute of Fundamental Research, Mumbai
15 June 2001

Chromospheric Magnetic Field of Solar Active Regions
Debi Prasad Choudhary
Udaipur Solar Observatory
19 June 2001

White Hole Model of Gamma Ray Bursts and Recent Observations
S.Ramadurai
Tata Institute of Fundamental Research, Homi Bhabha Road, Mumbai
03 July 2001

Beyond Uranium - An island of Balonium?
D.L.Lambert
University of Texas at Austin, USA
04 July 2001

Has the Art of Abundance Analysis Become Too Easy?
D.L.Lambert
University of Texas at Austin, USA
05 July 2001

Understanding the Morphology of Extragalactic Sources
Paul.J.Wiita
Georgia State University, USA
04 July 2001

High Resolution Observations of Supernova Remnants: Exploiting Chandra's Sub-Arcsecond
David Burrows
Penn State University, USA
20 July 2001

Experiments on Trapped Calcium Ions
M.Block
University of Mainz
Germany
24 August 2001

Search For Extra-Solar Planets
Peter A.Wehinger
Steward Observatory
University of Arizona,USA
28 August 2001

High Temperature Superconductors: What can we learn from a Variational Wavefunction?
Arun Paramekanti
Tata Institute of Fundamental Research,
Mumbai
07 september 2001

Large Optical telescopes and Liquid Mirror Technology
Paul Hickson
Dept. of Physics & Astronomy
University of British Columbia
10 September 2001

Near-IR and Optical Monitoring of Symbiotic Stars and Related Objects
Joanna Mikolajewska
N.Copernicus Astronomical Center
Warsaw, Poland
18 September 2001

The Fine Guidance System on NGST
John Hutchins
Dominion Astrophysical Observatory
Canada
20 September 2001

Electron and Neutron Electric Dipole Moments in the Minimal Supergravity Scenario and the possibility of Having moderately large CP-Violating phases with naturalness
Utpal Chattopadhyay
Tata Institute of Fundamental Research, Mumbai
27 September 2001

Observational Results of Coronal And transition Region Oscillations as seen from Soho
Dipankar Banerjee
Centre for Plasma Astrophysics
Leuven, Belgium
22 October 2001

Colliding CMEs
N.Gopalswamy
Catholic University of America
Washington D.C.USA
23 October 2001

Warm & Hot IGM
Biman Nath
Raman Research Institute
Bangalore
31 October 2001

Near Infrared Study of the Inner Milky Way
U.C.Joshi
Physical Research Laboratory,Ahmedabad
29 October 2001

Warm & Hot IGM
Biman Nath
Raman Research Institute
Bangalore
15 November 2001

CMBR: Smoking Gun with Finger Prints
T.Padmanabhan
IUCAA, PUNE
20 November 2001

Millimeter Observations of Dust and Molecular Emission in High Redshift AGN
Alain Omont
Institut d'Astrophysique de Paris, France
29 November 2001

Implications for the 11 yr Solar Irradiance Variations From Dynamo Theory
Valerji Pipin
Institute for Solar-Terrestrial Physics, Irkutsk, Russia
05 December 2001

Spectropolarimetery at Themis
Helene Frisch
Observatoire de la Cote d'Azur, Nice, France
18 December 2001

The Nucleon and the Neutron Star
Vikram Soni
NPL, Delhi
19 December 2001

Spin Distributions for Quantum Bipartite Systems
A.R.Usha
Bangalore University
21 December 2001

Bose Einstein Condensation and the 2001 Physics Nobel Prize
Ananth Chikkatur
MIT, Cambridge, USA
24 December 2001

Back to the Early Universe by Optimal Mass Transportation
Uriel Frisch
Observatoire de la Cote d'Azur Nice, France
28 December 2001

Recent Studies of Solar Wind, Cosmic Dust and Terrestrial Soils
D.Lal
University of California, San Diego, USA
15 January 2002

Ultrahigh-Energy Cosmic Rays: What we may Learn From Them
Gunter Sigl
Institut d'Astrophysique de Paris, Paris, France
22 January 2002

How are the Galaxies Distributed ?
Somnath Bharadwaj
IIT, Kharagpur
29 January 2002

Infrared Stellar Spectroscopy and the Oxygen Abundance Debate
Suchitra Balachandran
University of Maryland, USA
19 February 2002

Many-Body Effects in Metals and a Model for High-Temperature Superconductivity.
S.M.Bose
Drexel University
26 February 2002

Standard Model of Particle Physics and The Early Universe
AFSAR ABBAS
Institute of Physics, Bhubaneswar
15 March 2002

Neuro-Endocrinology: Linking Body, Mind and Consciousness
N.Kochupillai
All India Institute of Medical Sciences, New Delhi
15 March 2002

On an Increase of Polar Magnetic Flux of the Sun in the Last 120 years
V.I.Makarov
Pulkovo Astronomical Observatory
196140, Saint Petersburg, Russia
19 March 2002

Infrared Region of QCD and Confinement
R.Parthasarathy
Institute of Mathematical Sciences, Chennai
20 March 2002

Security Implementation in IIA LAN
Avinash Shenoy
Exocore
21 March 2002

APPENDIX C

Vainu Bappu Observatory

Time Allocation during 2001-2002

I. VBT		Total No. of Proposals received	31
	a.	No. of Spectroscopic Proposals	19
	b.	No. of Photometric Proposals	12
	c.	Total No. of Nights requested	256
	d.	No. of Nights requested for Spectroscopic work	168
	e.	No. of Nights requested for Photometric Work	88
II. 102-cm		Total No. of Proposals received	24
	a.	No. of Spectroscopic Proposals	18
	b.	No. of Photometric Proposals	6
	c.	Total No. of Nights requested	109
	d.	No. of Nights requested for Spectroscopic work	147
	e.	No. of Nights requested for Photometric Work	52

Sky conditions at Vainu Bappu Observatory

Year	Month	Spectroscopic Hours	Photometric Hours
2001	April	130	22
	May	103	22
	June	63	–
	July	39	–
	August	42	–
	September	53	2
	October	57	23
	November	110	24
	December	159	82
2002	January	151	49
	February	224	115
	March	220	60
	Total	1351	399

Sky conditions at IAO, Hanle

Year	Month	Photometric (night hrs)	Spectroscopic (night hrs)	Total (night hrs)
2001	April	105	133	240
	May	103	146	217
	June	38	116	210
	July	63	144	217
	August	108	158	248
	September	109	181	270
	October	195	270	310
	November	250	272	330
	December	189	226	341
2002	January	226	277	341
	February	87	129	280
	March	172	203	279
	Total	1645	2255	3283

Kodaikanal Observatory

Spectro / Photoheliograms and Seeing Conditions at Kodaikanal

Year	Month	No. of photographs in				Seeing*				
		Hα	Kfl	HαPr	PHGM	5	4	3	2	1
2001	April	17	19	15	20	–	3	10	7	–
	May	20	20	19	22	–	1	12	7	2
	June	6	6	6	10	–	–	7	2	1
	July	10	9	7	11	1	–	10	–	–
	August	14	13	13	21	–	2	12	4	3
	September	15	12	13	23	–	4	14	5	–
	October	6	5	6	16	–	1	6	5	4
	November	11	10	12	19	–	1	8	10	–
	December	16	17	13	18	–	10	4	3	1
2002	January	17	14	16	16	–	2	20	1	–
	February	17	14	16	23	2	5	12	2	2
	March	28	28	25	30	–	7	18	5	–
	Total	168	161	153	236	3	36	133	51	13

Kfl = K–flocculus
HαPr = Hα Prominence
PHGM = Photoheliogram

*(1–Very poor, 2–Poor, 3–Fair, 4–Good, 5–Excellent)

Solar Tower Tunnel Observations

Year	Month	Total Number of days of observations	Seeing (in arc sec) 1 to 2	2 to 3	3 to 4	4 to 5	>5 poor
2001	April	19	–	19	–	–	–
	May	22	–	17	3	2	–
	June	8	–	7	1	–	–
	July	14	–	14	–	–	–
	August	18	–	9	1	8	–
	September	17	1	15	1	–	–
	October	14	–	14	–	–	–
	November	17	–	17	–	–	–
	Dec	16	–	16	–	–	–
2002	Jan	20	–	20	–	–	–
	Feb	21	–	19	1	1	–
	Mar	–	–	–	–	–	–
	Total	186	1	167	7	11	–