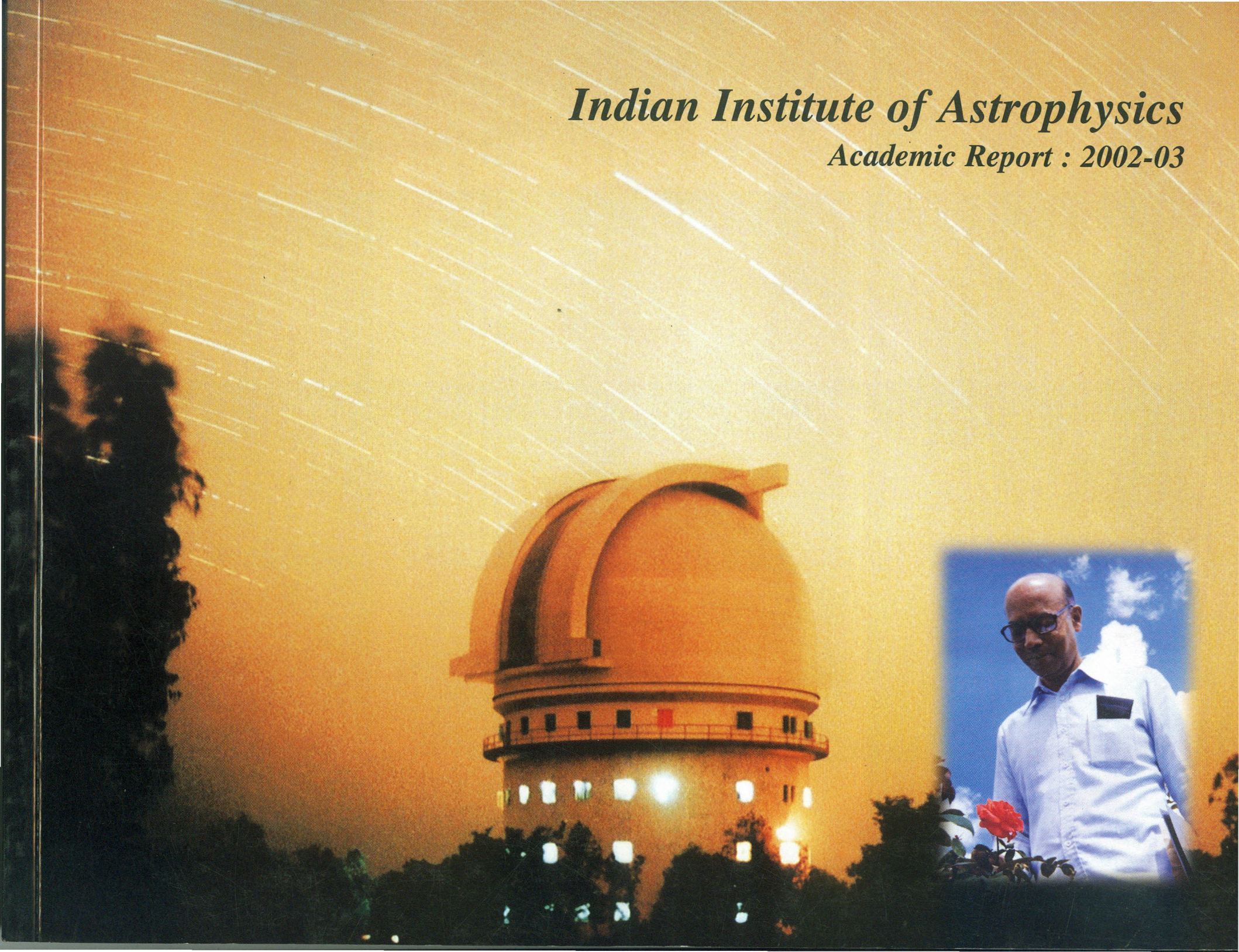
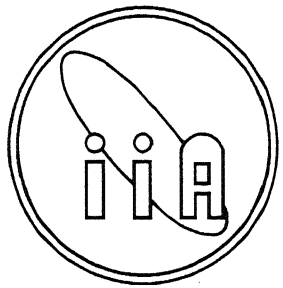
Indian Institute of Astrophysics

Academic Report : 2002-03



INDIAN INSTITUTE OF ASTROPHYSICS



ACADEMIC REPORT
2002-03

Edited by : R.C. Kapoor

Editorial Assistance : Sandra Rajiva

Front Cover : From the poster of a symposium in celebration of Prof. M.K.V. Bappu's 75th birth anniversary

Back Cover : The 2.34m Vainu Bappu Telescope, Vainu Bappu Observatory, Kavalur

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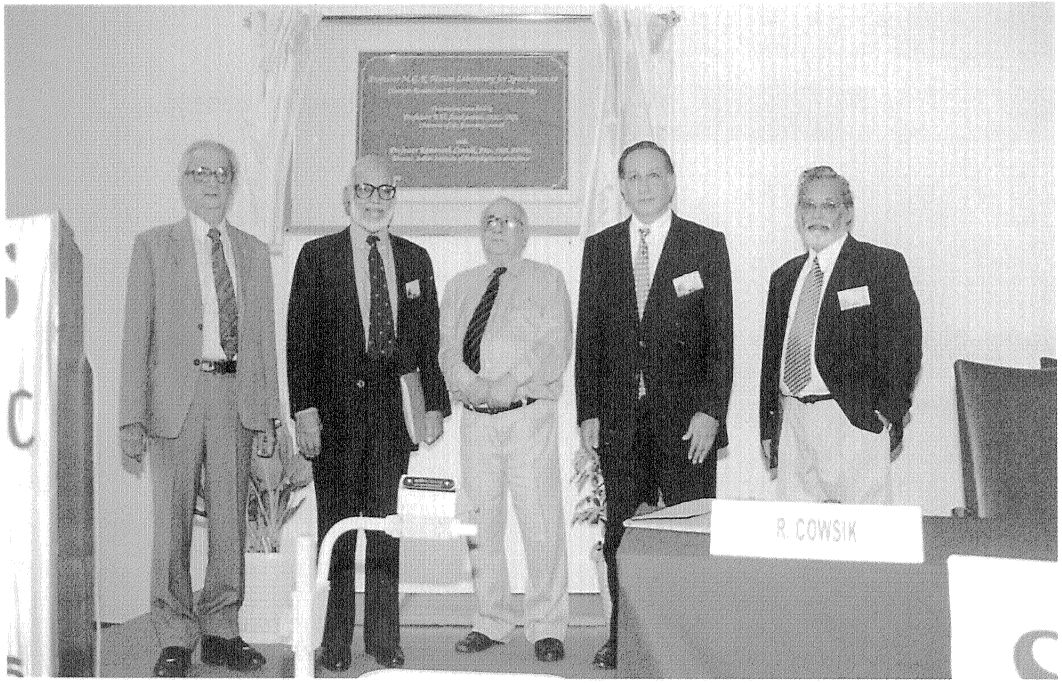

Inauguration of the Symposium 'Sun, Stars and the Extragalactic Universe' on August 8, 2002; seen here are L-R Professors B.V. Sreekantan, M.G.K. Menon, J.C. Bhattacharyya, R. Cowsik and N. Kameswara Rao.

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Bangalore 560 080.

Honours & Awards :

G.C. Anupama

- Awarded the Govt. of Karnataka's Sir. C.V. Raman Young Scientist Award for the year 2001 in Space Sciences.

R. Srinivasan

- Awarded the Astronautical Society of India Award 2000 - Space Science & Applications

Christina Birdie

- Awarded the SLA Diversity Leadership Development Award for the year 2003.

C. Sivaram

- Awarded Honorable Mention for his paper "Black Hole Thermodynamics need not constrain varying constants" from the Gravity Research Foundation, Massachusetts, USA, (2003).

Honourable Members of the Parliamentary Standing Committee on Science and Technology, Environment and Forests during their visit to CREST, Hosakote on September 7, 2002.

The year in review

The year 2002-03 has been remarkable in many ways. The Indian Astronomical Observatory at Mt. Saraswati in Hanle has matured with a full compliment of focal plane instruments which includes the versatile Faint Object Camera and Spectrograph. As anticipated, the Observatory has started playing an important role in the observations of time varying astronomical phenomena such as the gamma-ray bursts. The proposal by Professor N. Kameswara Rao to carry out astronomy from telescopes aboard Indian satellites got a major technical boost by the inclusion of Professor S.N. Tandon of IUCAA in the UVIT team. From the perspective of the management of the Institute important changes were anticipated. These changes were motivated, in part, by my wanting to focus more fully on research and other academic matters without the demands on my time by routine administration of the Institute. Accordingly Professor R. Srinivasan was appointed as the Officiating Director from December 1, 2002 until the return of Professor J.H. Sastri in the first week of April 2003 from his sabbatical.

The major new initiative this year is in the field of ground-based gamma-ray astronomy, a programme initiated in collaboration with the Tata Institute of Fundamental Research. An invitation has been extended to the interested scientists from Bhabha Atomic Research

Shri Bachi Singh Rawat, Hon'ble Minister of State for Science & Technology, Govt. of India, visited CREST on 26th December 2002. Here in conversation with scientists of the Institute.

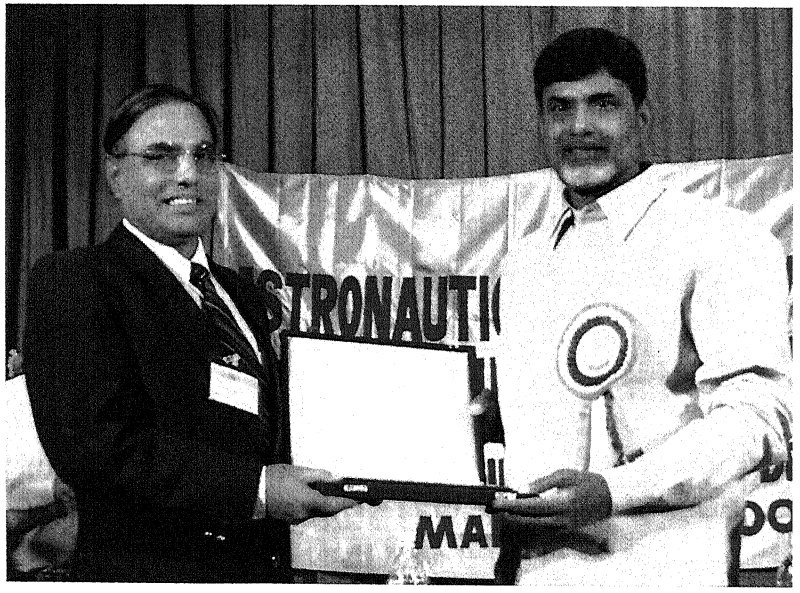
Centre and they are likely to join. It is anticipated that this activity, located in Hanle, will be capable of bridging the energy gap in the observations between the satellite borne Compton Gamma Ray Observatory and the ground based efforts using the imaging technique pioneered by the Whipple Observatory. The targeted energy range is from about 25 GeV to about 250 GeV wherein important astrophysical processes like inverse-Compton scattering and synchrotron processes

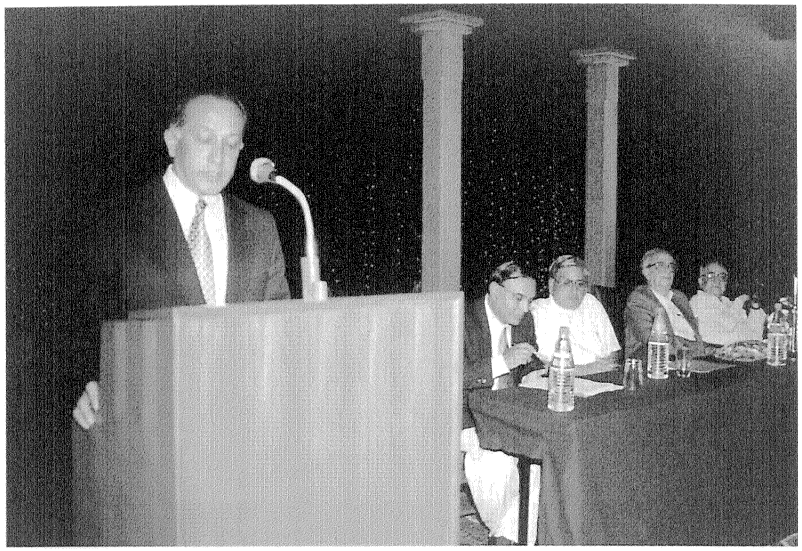
will condition the spectra; thus observations in this range will help in understanding the processes taking place in the powerful astronomical objects like active galactic nuclei, blazars and quasars.

This year's annual report contains descriptions of the variety of scientific activity and the staff welfare measures carried out at the various campuses of the Institute like the Indian Institute of Astrophysics in Bangalore, the Vainu Bappu Observatory in Kavalur, the Kodaikanal Observatory, the Radio Observatory in Gauribidanur, the Indian Astronomical Observtory in Hanle and the CREST campus in Hosakote. I would also like to draw attention to the active public outreach programmes carried out by my colleagues and to the several awards and distinctions conferred on members of the Institute.

Ramanath Cowsik
Director

Shri Chandrababu Naidu, Hon'ble Chief Minister of Andhra Pradesh, giving the award 2000 - Space & Applications of The Astronautical Society of India to Prof. R. Srinivasan

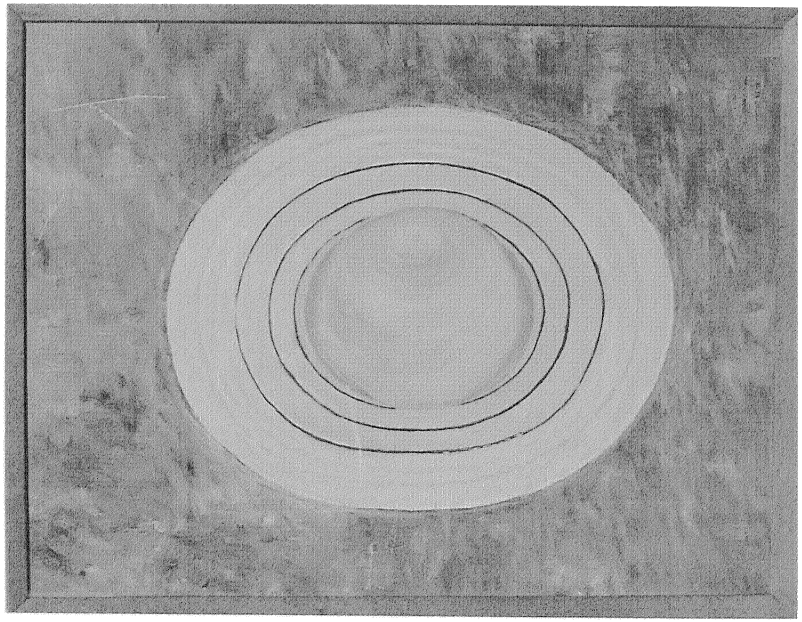




Professor Ramanath Cowsik at the CREST, Hosakote on 28-4-2002 when he was felicitated by the staff members on being conferred the Padma Sri award. Seated L-R : Professors R. Srinivasan, J.H. Sastri, B.V. Sreekantan and J.C. Bhattacharyya.

Professor D.L. Lambert in conversation with media persons on the occasion of the Symposium 'Sun, Stars and the Extragalactic Universe'.

Dr. G.C. Anupama receives the Sir C.V. Raman Young Scientist Award for the year 2001 in Space Sciences from Shri K.H. Ranganath, Honorable Minister for Forest, Karnataka Government, in the presence of Ms. Nafees Fazal, Honorable Minister of State for Science & Technology and Indian Systems of Medicine & Homeopathy and Prof. R. Narasimha, Director NIAS, on February 28, 2003.



The planet Uranus with its rings, a painting by M.K. V. Bappu (c. 1977)

SCIENTIFIC RESEARCH

1. Sun and the solar system

The Indian Institute of Astrophysics is engaged in research covering almost the entire area of astronomy and astrophysics. The Kodaikanal Observatory has facilities for observational work on the Sun and solar terrestrial physics whereas theoretical work is pursued mainly at the Bangalore campus.

Periodicities in the occurrence of solar coronal mass ejections : Solar coronal mass ejections (CME) are dynamic events of blobs of plasma which originate from the sun and affect the natural environment of the earth and the planets. These events involve significant ejection of masses from the sun, typically ~ 10^{15} to 10^{16} grams and energies ~ 10^{31} to 10^{32} ergs. These disturbing events play a major role in producing storms in the earth's magnetosphere and ionosphere, which in turn are responsible for the enhanced auroral activity, satellite damage and power station failures on the earth. It would be useful to minimise these disasters in case CME occurrences found to be periodic in nature and detected well in advance. We have undertaken such a study for the first time for the observed period of 1996-2001 and the results are as follows.

The Fourier analysis of the CME occurrence data observed by the SOHO satellite shows significant power around 1.9 yr., 1.2 yr., 265 day, 39 day and 26 day periodicities which are almost similar to the periodicities detected in the Fourier analysis of underlying activities of the photosphere. The wavelet analysis of CME occurrences also shows significant power around such periods which occur near the peak of solar activity. For the sake of comparison, the occurrence of H-alpha flares (supposed to be closely related with the CME) are subjected to Fourier and wavelet analyses. The well-known periods (1.3 yr., 152 day, 27 day) in the flare occurrences are detected. The wavelet analyses of both the occurrences show that the long period flare activity, especially for the period 1.3 year, lags behind the long period CME activity nearly by six months.

(K. M. Hiremath)

Long period global quiet coronal oscillations : We continued the search for the long period solar coronal oscillations from the unevenly spaced data of globally averaged radio fluxes (at 275, 405, 670, 810, 925, 1080, 1215, 1350, 1620 and 1755 MHz) and the results are as follows. The Fourier analysis of the data yields the following dominant periodicities whose powers are greater than 4 σ level : (i) 274 and 110 day periodicities for all the flux values, (ii) 25 day in the 1755, 1620, 1350, 1215, 1080, 925, 810,670 flux values, (iii) 26.1 and 19.6 day periodicities in the 275 and 405 flux values and, (v) 23 and 14.8 day periodicities in the 275 MHz flux value only.

In order to confirm the oscillatory nature of these waves, we compute phases of 25 day, 110 day and 274 day periodicities with respect to their different radio frequencies which originate at different heights in the corona and find that their phases remain constant for the flux values 1755 MHz (originating approximately at the altitude of 70,000 km) to 670 MHz (originating approximately at the altitude of 1,30,000 km) suggesting standing oscillations in this region of the corona. However, phases of these periodicities are not constant for the 405 MHz and 275 MHz flux values.

(K. M. Hiremath)

Long-term variations in solar differential rotation : The work on the study of cycle-to-cycle variations in the solar differential rotation, using Greenwich data on sunspot groups during 1879–1975, was continued (from previous year). We analysed also the SOON/NOAA data on sunspot groups during 1976-2002. We detected a big drop in the equatorial rotation

rate (A) from cycle 21 to cycle 22 by about the same amount as that of the known big drop in A from cycle 13 to cycle 14. We also detected a moderate drop in A from cycle 17 to cycle 18. From cycle 13 to cycle 14 the drop in A was larger in the northern hemisphere than in the southern hemisphere, it was opposite in the later two epochs. The time gap between any of the aforesaid two consecutive drops in A is about 4 solar cycles period, i.e., about 44 years, suggesting the existence of double Hale cycles (DHCs) in A. The time gap between aforesaid two big drops is about 90 years, suggesting the existence of a Gleissberg cycle (GC) in A. We also detected the existence of a GC in the latitudinal gradient (B) of the rotation. The GC in B began during cycle 14 and ended during cycle 21 with maximum $|B|$ during cycle 17.

We found that the big/moderate drops in A occurred at quarters of the approximate 179-yr cycle, 1811-1989, in the variations of Sun's orbital motion related to the center of mass of the solar system. The '90 yr' cycles seen in A and B are in the second half of the 179-yr cycle, 1811-1989. The Sun's orbital angular momentum varies by about 4.4×10^{47} g cm^2 s^{-1}. As indicated by the variations in A, the Sun's spin momentum also varies by the same order during the aforesaid epochs. All these suggest that the perturbations needed for the variations in the solar differential rotation (and hence for the variations of solar activity) may be coming from solar system dynamics.

(J. Javaraiah)

Predictions of the strengths of long-term variations in sunspot activity : Using the results above, we have made the following predictions: (i) The D_{sum} (sum of the amount of sunspot activity over the period of a double Hale cycle, DHC) of the current DHC 6 in sunspot activity which follows the big drop in A from cycle 21 to cycle 22 is expected to be less than that of the DHC 5 (consists of sunspot cycles 18-21). The D_{sum} of the DHC 7 which will follow a moderate drop in A from cycle 25 to cycle 26 is expected to be larger than that of DHC 6; (ii) within DHC 6 the H_{sum} (sum of the amount of sunspot activity over a Hale cycle, HC) of the preceding HC 11 (cycles pair 22, 23) is expected to be less than that of the following HC 12, within DHC 7 the H_{sum} of the preceding HC 13 is expected to be larger than that of the following HC 14; (iii) the current Hale cycle, HC 11 is most likely to violate the Gnevyshev and Ohl (1948) rule in cycles pairing; (iv) cycles 25 and 29 are expected to be relatively stronger than cycles 26 and 30, respectively; (v) it seems the present GC of B is started during cycle 22, expected to have maximum $|B|$ during cycle 25 and ends during cycles 29-30; and (vi) the beginning of the Maunder minimum might have followed a big drop in A which might be about 10 times larger than a big drop during the modern time and related to the near complete absence of activity during the deep Maunder minimum.

(J. Javaraiah)

'1.3-Year' and '153-day' periodicities in Sun's surface rotation : Using the daily Mt. Wilson velocity data during 1986–1994, we

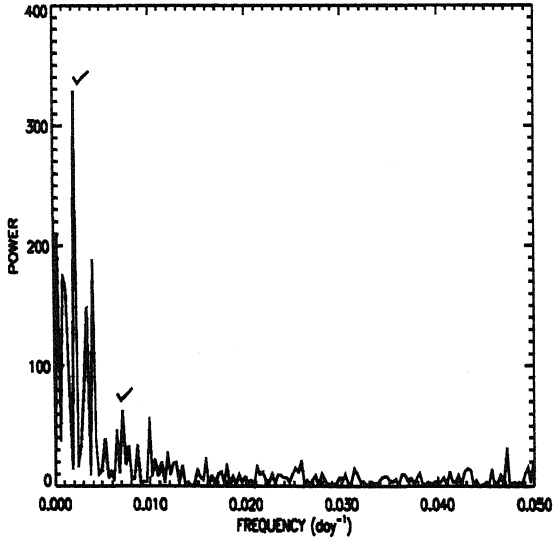


Figure 1. Power spectrum of the daily values of $\bar{A}$ during 1986-1994. The peaks at the frequencies corresponding to 1.3-yr and 153-day periodicities in $\bar{A}$ are indicated by tick marks.

found 1.3 ± 0.1 yr periodicity is dominant (with 23σ level, the FFT spectrum is shown in Figure 1) in the Sun's surface 'mean' rotation rate ($\bar{A}$) during 1986–1994 (solar cycle 22) (Figure 1). A 153 ± 5 day periodicity in $\bar{A}$ found to be significant on 3σ level, and it found to be significant on 6σ level during the decay phase of solar cycle 22. The 1.3-yr periodicity in $\bar{A}$ may be related to the 1.3-yr periodicity seen in variations of the Sun's internal rotation rate near the base of the convection zone (Howe et al. 2000, Science **287**, 2456). The aforesaid both periodicities in $\bar{A}$ may be related to the similar periodicities seen in sunspot activity (e.g., Krivova & Solanki 2002, A&A **379**, 701).

(J. Javaraiah)

Differences in solar rotation during positive and negative polarity solar cycles : It is believed that Hale's 22-yr magnetic cycle is the basis for all solar activity. The polarity of the solar polar magnetic field is changing after 1 or 2 years after the maximum of each sunspot cycle. Using Greenwich data on sunspot groups during 1879-1976, we determine the solar differential rotation rate during positive and negative polarity solar cycles (PPSC and NPSC, respectively). The results found were as follows: (i) During PPSC the equatorial rotation is faster (at a significance level of 2σ) and the latitudinal gradient of the rotation is greater (at 4σ) than during NPSC, and (ii) the north-south asymmetry in the equatorial rotation rate found to be 3σ in NPSC while in PPSC it is found to be not significant (only 1σ level). We also found that the Earth's rotation rate is different in PPSC and NPSC. The differences also exist in solar wind and interplanetary magnetic field parameters during PPSC and NPSC. All these suggest that the solar wind may be mediating the transfer of angular momentum from the Sun to the Earth.

(J. Javaraiah, K. Georgieva* and B. Kirov*)

Physical properties of coronal structures : Spectra around the 6374 Å [Fe X] and 7892 Å [Fe XI] emission lines were obtained simultaneously with the 25-cm coronagraph at Norikura observatory covering an area of 200″ x 500″ of the solar corona. The line-width, peak intensity and line-of-sight velocity for both the lines were computed using Guassian fits to the observed line profiles at each location (4″ x 4″) of the observed coronal region. The line-widths measurements show that in steady coronal structures the FWHM of the 6374 Å emission line increases with height above the limb with an average value of 1.02 Å arc sec^{-1}. The FWHM of the 7892 Å line also increases with height but at a smaller average value of 0.55 mÅ arc sec^{-1}. These observations agree well with our earlier results obtained from observations of the red, green, and infrared emission lines that variation in FWHM of the coronal emission lines with height in steady coronal structures depends on plasma temperatures they represent. The FWHM gradient is negative for high temperature emission lines, positive for relatively low temperature lines and small for emission lines in the intermediate temperature range. Such a behaviour in the variation of FWHM of coronal emission lines with height above the limb suggests that it may not always be possible to interpret an increase in the FWHM of emission lines with height as an increase in the non-thermal velocity, and hence rules out the existence of waves in steady coronal structures.

(Jagdev Singh, Takashi Sakurai*, Kiyoshi Ichimoto* and S.Muneer)

Nature of tilt angles of sunspot groups during 22nd solar cycle : Daily white light images from Kodaikanal observatory have been utilized to study the nature of tilt angles of sunpost groups during the 22nd solar cycle. 2416 spot groups have been measured to find the tilt angle. An average tilt angle of +4.6 ± 0.4 deg. has been obtained for all these spot groups, where the positive sign indicates that the leading part of the group is directed towards the equator. It is found that the number of poleward and

equatorward spot groups showed an opposite trend as the cycle advanced. The spot groups with positive (equatorward) tilt angles declined in their number whereas the spot groups with negative (poleward) tilt angles increased towards the end of the cycle. It is also noticed that a number of spot groups, which changed its sign of tilt angle during their lifetime or passage across the disc, increased during the maximum activity period of the cycle. These findings were confirmed from the analysis of the data from the 21st cycle. These results are discussed along with the daily variation of tilt angles of some of the spot groups from the selected data.

(S. Muneer and Jagdev Singh)

Variation in the network flux as derived from the calcium K line profiles as function of latitude and solar cycle phase : We have obtained the Calcium K-line profiles, on daily basis, at all latitudes, while integrating the spectrum over the visible longitudes of the Sun by moving a ~ 340 mm solar image at a uniform speed in the E-W direction of the Sun. The spectra were recorded at a dispersion of 9.34 mm / Å on 35 mm Kodak 103-aO film of the time period of 1986-95. Then we started to obtain the spectra using 1k x 1k for liquid cooled CCD camera. We plan to study possible long-term variations in the chromospheric rotation rate, and changes in Polar regions with the phase of the solar cycle using various parameters of this line.

To determine the average contribution of the network to the K-line flux, K_1-width and K_2-width, on a yearly basis, we have plotted these indices against the calcium K-plage areas. These areas are measured from the K-line spectroheliograms obtained at Kodaikanal Observatory for all the latitudes separately. We plot K-line flux (0.5 A) for all the latitude belts versus K-plage area and find the component of network flux with the linear fits. We assume that the value of intercept at zero plage area gives the contribution due to network flux. We plan to compute these values for each year and then study the variation in network flux at different latitudes over an interval of 5 degrees, and with the phase of solar cycle,

The plots of K_1 width and K_2 against K-plage area indicate that K_1-width increases with plage area whereas K_2 width decreases with plage area. We computed these parameters for zero plage area from the linear fits to the data for each latitude belt.

We plan to use these data to study the following :

1. The sunspots and related features give information only between 10 to 40 degree latitude belts whereas this method will yield information about the polar regions as well.
2. We would get plage free profiles at all latitude belts during the different phases of the solar cycle, which would make it possible to study the changes in the active network as a function of the solar cycle.
3. The power spectral analysis of the K-index (Singh and Livingston, 1987) for different latitude belts would provide information on the chromospheric rotation as a function of latitude and hence would help to establish the chromospheric differential rotation rate.
4. Singh and Prabhu (1985) have shown, from the analysis of plage areas, that chromospheric rotation rate varies with time, but the analysis is restricted to only few latitude belts due to the occurrence of plages in those latitudes. The analysis of the present data may yield the values of rotation rate with time in all latitudes, and thus would help explain the slow and fast rotating bands on the solar surface.
5. The data will also be used to correlate K-index of the Sun as a star with the various UV, VUV and irradiance in the visible wavelength region measured from space experiments.

(Jagdev Singh, Iraj Gholami* and S.Muneer)

Digitization of Kodaikanal data : A program has been started by the Institute to digitize the large amount of data obtained since 1904 at Kodaikanal. We have used available contact printer as a uniform source of light. A UPS supplies the electricity to the light source to maintain the intensity level. A Nikon 28-105 mm lens with Micro facility is used to image the photographic plate onto the CCD camera. There is a provision to add 2X lens to obtain high spatial or spectral resolution while digitizing the smaller images. The Andor CCD camera has a 2048-formate scientific grade chip with pixel size of 13.5 micron. The Peltier cooled CCD camera can be cooled to –60°C using air circulation and to -70°C with water circulation. The digitized image can be read with 4-speed range between 31.25 kHz and 1 MHz. We have digitized a sample of spectrum, broadband image of the Sun, Hα and Ca^+ K spectroheliograms. The digitized data will be used to study the temporal variations in phtotospheric and chromospheric rotation rate, differential rotation, evolution sunspots & Hα filements, Ca^+ K plage and network index etc. The data will be made available to the Institute's archive. This program uses state of the art technology and hence much faster compared to earlier digitization programs at the Institute.

(Jagdev Singh, S. Munner, S.P. Bagare, K.E. Rangarajan, K.B. Ramesh, B.A. Varghese, J.P.A. Samson, P. Devendran and G. Hariharan)

Studies of chromospheric differential rotation and its variation with time from Ca-K plage areas : It has been shown that power spectral analysis of observed daily Ca-K plage areas yields chromospheric rotation rate. Singh and Prabhu (1985) analysed the measured plage areas for the year 1951-83 for the latitude 20-25, 25-30 North and South belts only. They found that the rotation rate at these latitude belts varies with quasi periodicities of 2,7 and 11 years. Now we have sketched the Ca-K plage areas for the remaining years of 1906-50 and have the data from 1984 to 2002. Part of the data on Ca-K plage areas have been measured and the remaining data is being measured. Logging the data in the computer is a time consuming process. The data for all the latitude belts at an interval of 5-degrees will be subjected to power spectral analysis to determine the rotation rate at each altitude belt for each year. Further analysis will be done to determine the periodicities in the variation of rotation rate if any. In addition, cross correlation technique will be used to study the phase difference between the variations in rotation rate, for different latitude belts. This will help us to determine the existence of fast and slow rotating bands if any and the speed of the bands, from equator to poles or vice versa.

(Jagdev Singh, S. Munneer, P.S.M. Aleem, R. Selvendran, G.S. Suryanarayana, P. Kumarvel, P. Michel, P. Devendran and G. Hariharan)

Solar observational facility at Hanle : Members of the solar sub-group had a number of meetings and discussions to develop solar observational facility at Hanle in three phases, (i) to measure the day-time seeing conditions at the site using DIMM and other techniques (ii) to start synopatic observations of the sun to study solar activity and (iii) high resolution facility. To make the synopatic observations it was decided to install a solar telescope consisting of three telescope tubes mounted on a single drive unit with a fork mount. One tube will be equiped with 15-cm objective, a collimator, narrow band H-alpha filter of 0.5 Å passband tunable in the range of 1.6 Å, a camera lens to yield 24-25 mm image of the sun and a CCD camera of 2K x 2K format to provide pixel resolution of about 1 arcsec. Second tube will have specification similar to H-alpha telescope tube but filter will be centred around Ca-K line with 1 Å passband without any tuning. Third tube will be to obtain broad band images of the sun in blue light centered around 4500 Å. The proposed telescope may be operated remotely depending upon the availability of communication link. It may not be possible to download the large volume of entire data obtained but possible to download sample images. The remaining data can be sent to Bangalore by using other means.

After measuring the seeing conditions and estimating other parameters, and keeping in view the interests of the solar group, specifications of a large and state-of-art solar facility can be decided. It may be imaging facility if the day time seeing is good, a high resolution spectrographic facility in the UV or infrared as the water vapour in the air are negligible and sky transparancy is very high due to high altitude or a polarimetric telescope to investigate the nature of flux tubes.

(Jagdev Singh, S.P. Bagare, K.E. Rangarajan, K.B. Ramesh, R. Kariyappa, S.S.Hasan, R. Srinivasan, T.P. Prabhu)

H-alpha filtergrams at the Spectro : The H-alpha filter procured from Halle Company in the year 1979 provided high quality images. Over the years it developed some defects and provided images of low quality. The filter was repaired by a Chinese company recently. A provision was made to split the solar beam in two parts using 50 x 50 mm beam splitter in the existing telescope to take Ca-K line filtergrams. The transmitted component was fed to Ca-K line filter and the reflected light fed to the H-alpha filter. The H-alpha image quality has improved, shows filaments and other H-alpha structures and approaches the original quality. We have started obtaining the H-alpha filtergrams on a regular basis using 2415 Kodak 35 mm film. This film has gone out of production and we have a stock that may last for a year or so. Also the 70 mm films used for obtaining H-alpha and Ca-K spectroheliograms may last for a year or so. In view of these, we plan to start to record H-alpha filtergrams using 2k x 2k CCD camera from next year.

(Jagdev Singh, P.S.M. Aleem, G.S. Suryanarayana, R. Selvendran, P. Kumaravel, J.P.A. Samson, F. George, P. Devendran, P. Michel and G. Hariharan).

Variation of rotation rate with age of sunspot groups : We have for long dealt with the surface rotation rates of spot groups and individual spots. These studies used the measures of the sunspot positions and their umbral areas from the white-light images of the sun for the period 1906-1987 obtained at the Kodaikanal Observatory which form a unique data bank. A similar but shorter data bank exists at the Mount Wilson Observatory which has also been used for the rotation studies. The rotation rates determined in these studies are values averaged over spot groups of all ages. In the present investigation we have determined the variation of the rotation rates of spot groups as they age. Our data consists of spot groups of life-span ranging from 1 to 8 days. We find that the rotation rates averaged over spot groups of all life-spans show a deceleration as they age in the three latitude belts (averaged over the N and S hemispheres) : 0-10, 10-20 and 30-40 deg and a gentle acceleration in the 20-39 deg belt alone. This result, although is in agreement with the rotation rate vs age determinations from the Greenwich sunspot data by many earlier investigators, is in conflict with the concept of the evolution of the foot points of the magnetic loops of spot groups in the solar interior as the spot groups age. According to the widely accepted scenario (the flux tube anchoring model), the foot points of the magnetic loops of spot groups are initially anchored in the deeper layers in the solar interior and these foot points rise to shallower layers as the spots age and the rotation rates of spot groups measured on the surface at any time reflect the plasma rotation rates at the respective depths at which their foot points are temporarily rooted. Interpreted in terms of this scenario, the deceleration in the rotation rates observed as the spot groups age would mean that the deeper layers in the solar interior rotate at a faster rate than the layers above them. This is in direct conflict with the rotation profiles in the solar interior obtained from helioseismology observations which show that the rotation rates actually decrease with increase in depth in the solar interior. We reinvestigated this problem by first sorting out the spot groups life-span-wise into 8 bins, the first bin containing all spot groups of 1 day life-span, the second bin containing all spot groups of 2 day life-span and so on. We then determined the rotation rates of spot groups in each of these bins as the spot groups age. When this was done, we find that the spot groups in each of the life-span bins experience

acceleration (and not deceleration) in their rotation rates as they age. This acceleration is seen in all the 4 latitude belts. We show this result in Figure 2. We have done a similar analysis using the Mount Wilson sunpsot data set and find that the results are identical to those from the Kodaikanal data set. The acceleration in rotation rates confirms that the rotation rates decrease with increase in depth in the solar interior. With the aim of checking the validity of the flux tube anchoring model further, we projected that "first day rotation rate" of spot groups (which is the rotation rate on the first day of the life-span of spot groups) of life-span 1-8 days on the rotation profiles in the solar interior obtained from the helioseismology observations under the GONG Project. For example, we have marked the "first day rotation rates" (converted to rotation frequencies in nHz) of spot groups of life-spans 1 - 8 days in the latitude belt 0 - 10 deg determined by us on the helioseismology profile at the 5 deg latitude. The intercept marked 1 represents the location of the foot points of the magnetic loops of spot groups of 1 day life-span lying within the latitude belt 0 - 10°; intercept 2 represents the location of the foot points of loops of spot groups of 2 day life-span and lying within the latitude belt 0 - 10 deg and so on. Similarly for the other latitude belts.

We now read off the depths on the r/R_o axis corresponding to these intercepts for each latitutde and these give the depths at which the foot points of the magnetic loops of the spot groups are anchored on the first day of their lives. From this we find that the foot points of the magnetic loops of spot groups of very short life-span (1 -2 days) are initially anchored in the very shallow layers of depths $r/R_o \sim 0.95 - 0.90$. The initial anchoring depths progressively get deeper with increase of life-span and for spot groups of life-span 6 - 8 days these depths are around $r/R_o \sim 0.72$ (Figure 3) which corresponds to the base of the convection zone. This would mean that the foot points of magnetic loops of these spot groups with life-spans are initially anchored deep in the interior, in the layers below the base of the convection zone, while the foot points of the loops of those spot groups with short life-spans are anchored in the shallow layers close to the solar surface. To determine the progressive change in the location of the foot points of the magnetic loops as the spot groups age, we projected the daily rotation rates of spot groups (converted to

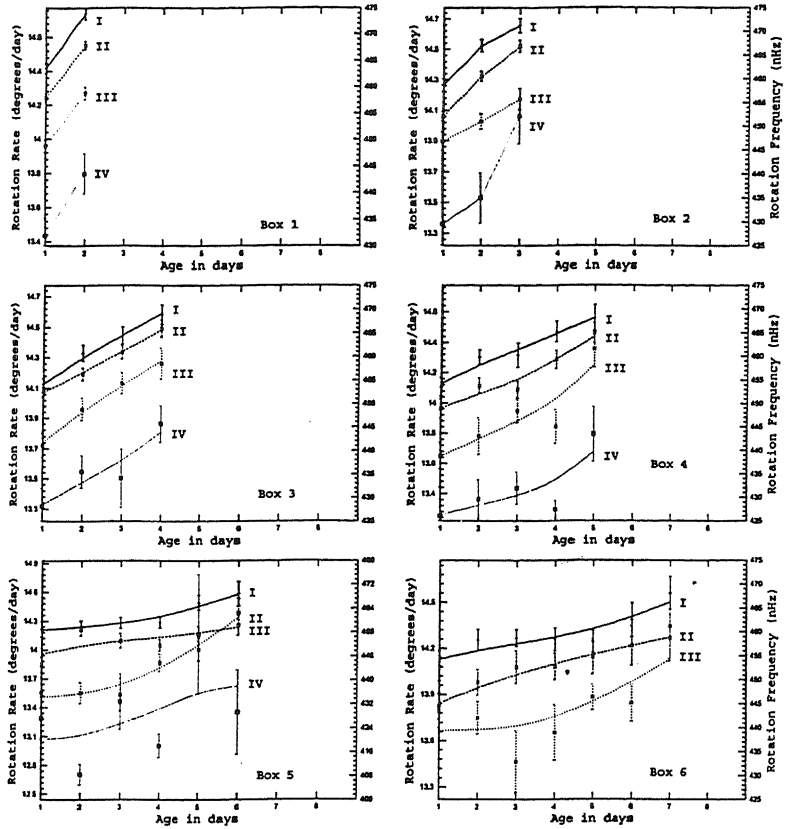


Figure 2. Siderial rotation rates (in degrees / day) vs age life-span-wise for spot groups of life-span 2 through 7 days are plotted in boxes 1 through 6 for the 4 latitude belts :

I = 0 – 10 ; II : 10 – 20 ; III : 20 – 30 ; IV : 30 – 40 deg.

The rotation rates in each latitude belt are averaged over the north and south hemispheres. Notice that the spot groups show acceleration in rotation rates as they age in all the four life – span categories and in all the 4 latitude belts.

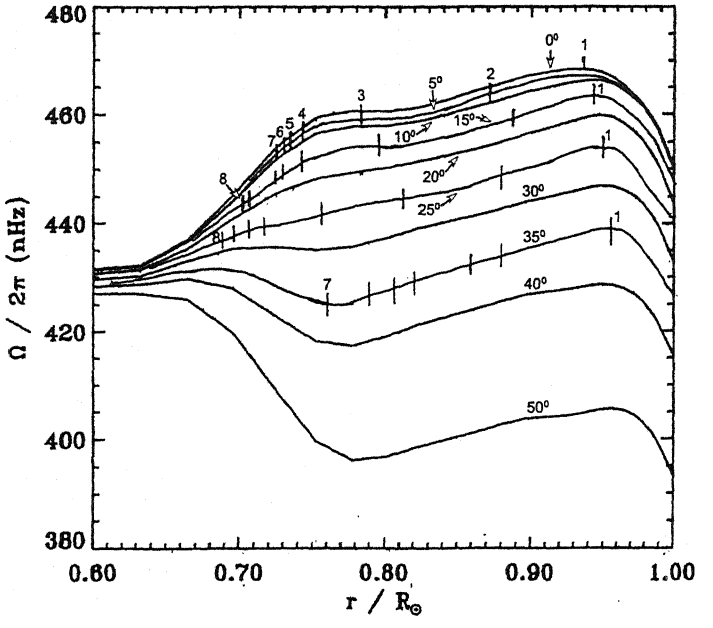


Figure 3. The first day rotation rates of spot groups of life – span 1 – 8 days expressed as rotation frequencies in nHz projected on the GONG rotation profiles for latitudes 5, 15, 25 and 35 deg representing the 4 latitude belts : 1 – 10 ; 10 – 20 ; 20 – 30 and 30 – 40 deg.

X axis : depth (r) in terms of the solar radius R_o

Y axis : rotation frequency in nHz.

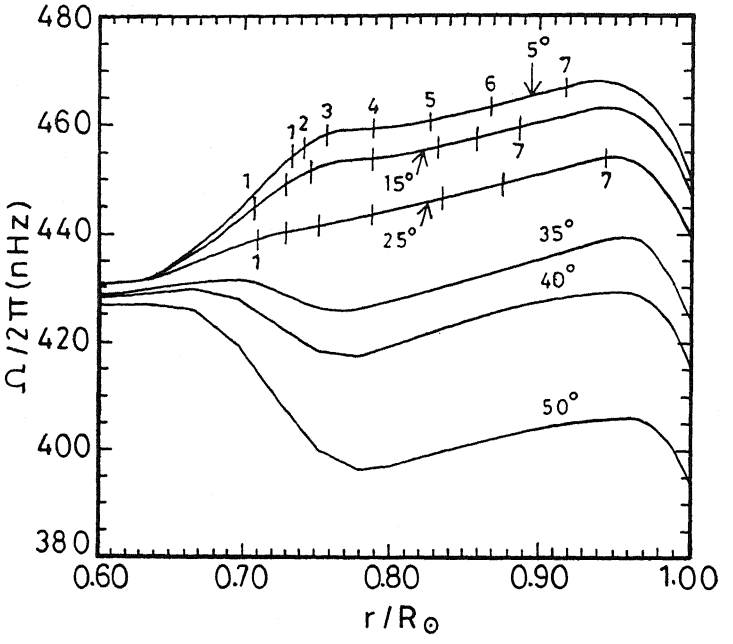


Figure 4. Rotation rates of spot groups converted to rotation frequencies in nHz projected on the GONG profiles for latitudes 5 ; 15 ; 25 and 35 deg representing the 4 latitude belts : 0 – 10 ; 10 – 20 ; 20 – 30 and 30 – 40 deg. for the 7 – day life-span spot groups.

rotation frequencies in nHz) of all life-spans on the GONG rotation profiles in the appropriate latitude belts. In Figure 4 we show the plot for spot groups of 7 day life-span as an example. In this Figure, on the 5 deg profile, 1 represents the location of the foot points of the magnetic loops of spot groups on the first day of their lives, 2 represents the location to which the foot points have risen on the second day of their lives and so on. Finally 7 represents the location of the foot points of the loops on the seventh day of their lives in any latitude belt. The depths of location of the foot points of the loops are read off on the r/R_o axis corresponding to these intercepts. From this we find that the foot points of the loops of the long lived spots, initially anchored in the layers below the base of the convection zone, rise to shallower layers first at a slow rate (~ 10 -15 Mm/day) and on reaching depths of around $r/R_o \sim 0.85$ at a faster rate (~ 30 - 40 Mm/day). The excellent agreement of the pattern of variation of the surface rotation rates with age of spot groups with the internal rotation profiles from helioseismology established by this investigation has resolved the long standing problem between the variation of the surface rotation rates of spot groups and their connection with the rotation profiles in the solar interior and also has established the validity of the flux tube anchoring model which has so far been based on scientific intuition.

(K.R. Sivaraman, Hari Sivaraman*, S.S.Gupta and R.F. Howard*)

Intensity oscillations of the coronal x-ray bright points from SXT of Yohkoh observations : The relation of X-ray Bright Points (XBPs) with the underlying photospheric and chromospheric features is an important issue in understanding the origin of the footpoints of XBPs and hence to study the heating of the quiet corona. We have used a long time sequence of the full-disk soft X-ray images obtained at both low and high temporal resolution with soft X-ray telescope (SXT) of *Yohkoh* mission to bring out the differences, if any, in the period of intensity oscillations associated with XBPs. We derived the energy flux of the XBPs for the entire sequence and for the XBPs of 10-days observations selected during 1992, 1993 and 1994. The light curves of the XBPs have been produced. We classified the XBPs into three groups depending on their emission levels: (i) the quiet XBPs; (ii) less bright XBPs; and (iii) the very bright XBPs. The power spectrum analysis has been done using their energy flux values to determine the period of intensity oscillations. A significant periodic intensity variations with Fourier transform power peaks have been detected around 8 ± 0.61 hours and 1 ± 0.25 hour in the case of low temporal resolution of longer duration (more than 24 hours) of observations, although there are secondary peaks with smaller amplitude in power. We conclude that the XBPs are mainly associated with two kinds of period of oscillations in their intensity variations, namely the 8 ± 0.61 hours and 1 ± 0.25 hour. In a comparison among these three regions with different X-ray emission levels, we have found that the period of intensity oscillations is similar in all the cases. This can be taken as evidence to argue that heating mechanism in all the three groups of XBPs is similar. This confirms the similar argument drawn for the three classes of chromospheric CaII K bright points (Kariyappa, 1996, 1999 and 2002). The analysis of high temporal resolution with a shorter duration (about 2 hours and 30 minutes)of observations of XBPs show that they exhibit a shorter periodicity of 6-7 min in their intensity variations, although this is not seen in the longer duration of observations due to the low temporal resolution.

(R. Kariyappa, T. Watanabe*, B. A. Varghese and Y. Katsukawar*)

Two beam spectropolarimeter for Kodaikanal tower telescope : The tower telescope at Kodaikanal has high spatial resolution coupled with a good spectrograph having 11 mm per angstrom spectral resolution in the sixth order in the violet. A two beam spectropolarimeter is proposed to be built for use at the existing tower telescope facility. A single beam system is prone to high data acquisition time and seeing induced errors. In contrast, a two beam system would reduce the observation time because two polarization states can be simultaneously observed. It also mitigates the seeing induced errors partially. The main component of the two beam system is a Polarizing Beam Displacer (PBD) which splits the incoming ray into two orthogonally polarized directions. The two output beams are displaced by a specified amount but in the same direction of the incoming ray. The polarimeter also contains a quarter wave plate, a polarizer and a half wave plate.

(K.E. Rangarajan, K.B. Ramesh, Jagdev Singh and K. Nagaraju)

Period - brightness relationship in chromospheric bright points : The chromospheric bright points are the sites where an intense heating takes place by the 3-min period waves. A 35-min-long time series of photographic spectra in the CaII H-line on a quiet region at the center of the solar disk observed under high spatial, spectral, and temporal resolution at the Vacuum Tower Telescope (VTT) of the Sacramento Peak Observatory is used to show that the period of intensity oscillations seen at the sites of variety of bright points in the interior of the supergranulation cells is independent of their intensity enhancements. We find an evidence for the existence of the constant period of oscillations in bright points with their brightness and the different period from network oscillations, and this suggest that the mode of heating mechanism may be identical (by 3-min period waves) in any class of bright points and it may be an entirely different mechanism (by 5-7 min period waves) in the case of network elements. In addition, it has been shown that the amplitudes of the main and the follower pulses of variety of bright points decay exponentially with time and the decay rate is constant with their brightness in any class of bright points. We briefly mention the importance of

flux tubes and their role in heating of the hromosphere. A simple model of a flux tube with flows and the characteristics of Alfven Surface Waves is presented. The pressure amplitude of these waves are independent of the frequency (period) and decay away from the center of the flux tube. We suggest that the physical process behind the cause for the bright points may be due to the interference of 3-min period waves, and the 3-min bright points may be magnetic in origin.

(R. Kariyappa, A. Satyanarayanan, L. Dame*, M. Martic* and F. Kneer*)

Polar activity cycle : The two essential components of the global solar cycle are the sunspots (or the active regions) at latitudes between the equator and 40 deg N and S and the polar fields that cover the solar surface beyond the sunspot latitudes all the way to the poles. The large-scale unipolar regions are formed out of the flux dispersed from the sunspots as well as (independently) from the polar field flux elements. According to the commonly accepted scenario conceived by Babcock (1955) and modified later by Leighton (1964), the fragments of the flux elements from the active regions, as they decay are transported towards the poles by advection, diffusion and meridional circulation. These flux elements which are of opposite polarity to the existing polar fields, cancel the latter as they advance towards the poles and finally reach the poles (seen as the polar crown filaments) and reverse the existing polarity there. Makarov and Sivaraman have shown that this event termed as the polarity reversal at the poles, can be very picturesquely seen by tracing the migration of the H - alpha filaments which represent the neutral line between region of opposite magnetic polarities. Using the H - alpha data from the data archives of Kodaikanal and Kislovodsk solar station they have derived the filament migration charts (also known as the H - alpha synoptic charts) that show the migration and polar reversals for nearly 10 solar cycles (1910 - 2000). Once the existing polar fields are cancelled ,the polar fields of the next solar cycle appear in the latitudes above ~ 50 deg of polarity opposite to that of the previous polar cycle. This cycle of events repeats when this polar field is also cancelled by the advancing sunspot flux of the new cycle causing the next polar reversal and so on. One of the problems in the topic of the global solar cycle is to know precisely the duration of the polar magnetic activity. We have defined this as the interval between two successive epochs of reversal of the magnetic polarity at the poles and have determined these epochs by two different methods on the same data, namely, the H - alpha synoptic charts.

(1) from the time of disappearance of the polar crown filaments on the H - alpha synoptic charts as described above and (2) from the interval between two reversals for the dipole magnetic configuration (l = 1) which was derived by computing the spherical harmonic coefficients for the l = 1 mode. The analysis using the second method applied to the H - alpha synoptic charts (as well as the Stanford magnetograms) shows that the reversals for the magnetic dipole configuration (l = 1) occur on an average of 3.3 years from the last sunspot minimum. On the other hand if the epochs of the polar reversals are reckoned from the final disappearance of the polar crown filaments (method I) then these reversals are seen to occur on an average interval of 5.8 years from the last sunspot minimum. We consider the values of the duration of polar activity derived from the method (I) as more reliable and precise as the epoch of the final disappearance of the polar crown filaments can be determined very precisely from the H - alpha synoptic charts. When the durations of the polar activity are determined thus for cycles 11 - 23 (corresponding to the years 1867 - 1998) it is seen that the shorter the duration of the polar activity cycle (i.e the shorter the duration between two neighbouring reversals), the more intense is the sunspot activity in the following cycle. Thus the duration of the polar activity can be used as an index to predict the strength of the sunspot cycle which is to follow in about 4 - 5 years, Hence, this analysis has also brought out that the duration of polar activity is longer in even numbered cycles than in odd numbered cycles, whereas the maximum value of the sunspot Wolf numbers is always higher for odd numbered cycles than for the even numbered cycles.

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

East-West asymmetry and the Wilson-Effect : The study of east-west asymmetry in the properties of sunspots with regard to their measured Wilson Effect parameter - the penumbral width ratio in sunspots, was continued. It is found that the asymmetry properties depend on the magnetic type of the sunspot itself and also the surrounding magnetic topology in the photosphere. However, no significant east-west asymmetry is found in the actual 'occurrence rates' of any of the magnetic categories. The results also show a long term dependence of the Wilson-Effect parameter on the evolutionary phase of any given sunspot.

(S.P.Bagare, S.S.Gupta and Rabbi Angiras)

Molecular parameters for species observed in sunspots :

Molecular lines provide a good diagnostic tool to be explored for spectroscopic studies of sunspots since they are formed essentially in the cooler surroundings of umbrae and are devoid of contamination by scattering in the photosphere. Many species have been identified and their Zeeman effect have also been observed. However, many more diatoms remain unidentified either due to lack of spectroscopic data for the transitions or since they are too faint to be readily identified. We have estimated transition probabilities for AlF, PO, and GeO. Some of the bands of these species have already been identified in sunspot spectra while others are suspected to be present. Our computations suggest the presence of additional bands in the UV, visible, and in the near IR region, for these diatoms.

(S.P.Bagare, N.Rajamanickam*, and K.Balachandra Kumar*)

Dynamics and heating of the magnetic network on the Sun: Efficiency of mode transformation : We aim to identify the physical processes which occur in the magnetic network of the chromosphere and which contribute to its dynamics and heating. Specifically, we study the propagation of transverse (kink) MHD waves which are impulsively excited in flux tubes through footpoint motions. When these waves travel upwards, they get partially converted to longitudinal waves through nonlinear effects (mode-coupling). By solving the nonlinear, time-dependent MHD equations we find that siginificant longitudinal wave generation occurs in the photosphere typically for Mach numbers as low as 0.2 and that the onset of shock formation occurs at heights of about 600 km

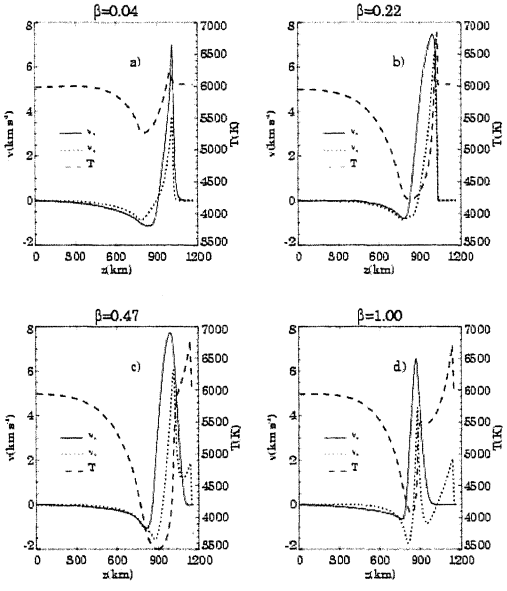


Figure 5. Snapshots of the transverse velocity v_x (*solid curves*) and longitudinal velocity v_z (*dashed curves*) and the temperature T (dashed curves) as functions of height z for (a) $\beta = 0.04$, (b) $\beta = 0.22$, (a) $\beta = 0.47$, and (d) $\beta = 1.00$.

above the photospheric base. We also investigate the compressional heating due to longitudinal waves and the efficiency of mode coupling for various values of the plasma β, that parameterizes the magnetic field strength in the network. We find that this efficiency is maximum for field strengths corresponding to $\beta \simeq 0.2$, when the kink and tube wave speeds are almost identical. This can have interesting observational impications.

(S.S. Hasan, and P. Ulmschneider*)

Reconstruction of the past total solar irradiance on short time scales : The aim of this investigation is to present a new analysis of short term variations in total solar irradiance by developing regression models, and to extend these to epochs when irradiance measurements were not available. In our models, the sunspot area is used to quantify sunspot darkening while facular brightening is calculated using facular area, 10.7 cm radio flux and Mg II core-to-wing ratio. Models developed with various proxies are compared with a view to identify the role of key parameters in solar variability. We also study the relationship between different facular proxies and show that the facular area and 10.7 cm radio flux do not vary linearly with the Mg II core-to-wing ratio. We emphasize that the facular term in current empirical models on short time scale needs to have a nonlinear component in order to obtain a better correlation with observed irradiance. Our analysis demonstrates that the correlation for daily variations in solar irradiance improves by 10% using a quadratic term in the model based on radio flux as a facular proxy which is a significant improvement on earlier models. On the other hand, the correlation remains unchanged in the model using Mg II core-to-wing ratio. Thus, we point out that various proxies for facular brightenings contribute differently to solar irradiance. We further estimate the solar irradiance variations at epochs without observations, in particular back to the start of the radio flux measurements, and find that there is no drastic increase in radiative output during the most active solar cycle 19 while for cycle 20 we observe a sudden decrease in irradiance.

(Kiran Jain and S. S. Hasan)

Metric observations of transient, quasi-periodic radio emission from the solar corona in association with a 'halo' CME : It is well known that the fundamental plasma parameters in the solar corona are important to the understanding of solar flares, to the acceleration of solar wind and coronal mass ejection (CME), and, ultimately, to Sun-Earth connection. The recent observations of oscillations in coronal loops using TRACE data (a space mission for observing the Sun at EUV wavelengths) has now raised the feasibility of the development of em coronal seismology, analogus to helioseismology which provides us with powerful

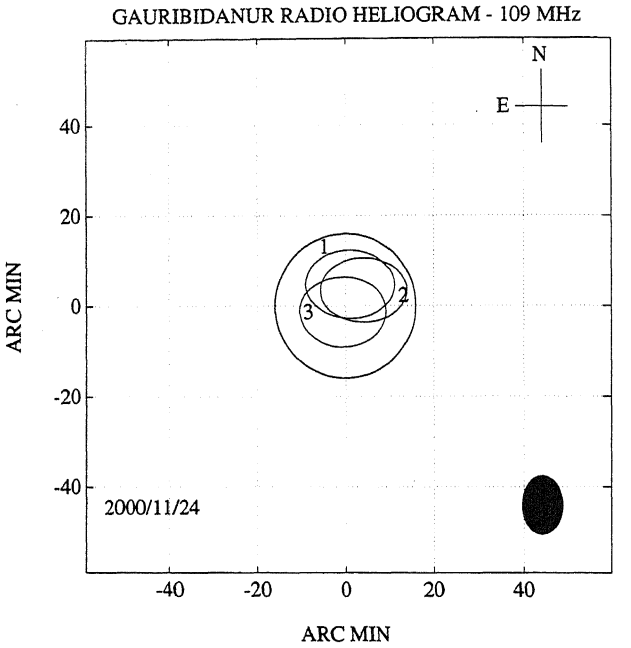


Figure 6 : Half-power contours of the radioheliogram obtained with the GRH on November 24, 2000 at 04:58:54 (1), 04:59:21 (2) & 04:59:47 UT (3), the various stages of the observed quasi-periodic radio emission : The estimated peak radio brightness temperature is approx 2.92×10^8 K and it corresponds to the image obtained at 04:59:47 UT. The open circle at the center is the solar limb. The size of the GRH beam at 109 MHz is indicated at the lower right corner.

results concerning the interior of the Sun. The seismic information offers the means of determining local conditions, particularly the coronal magnetic field which is generally inferred mainly from measurements of the line-of-sight component of the photospheric magnetic field. The observations of transient, pulsating radio emission from the solar corona is a potential diagnostic tool in this connection since radio data can be obtained with a high temporal and

spectral resolution. We estimated the plasma parameters in the solar corona in an independent manner from the quasi-periodicity in the radio burst emission observed with the Gauribidanur radioheliograph (GRH) on November 24, 2000 (Figure 6 & 7). The radio event lasted for about 60 sec. Its mean periodicity was approx 8.8 sec. The estimated Alfv'èn speed in the corona was $\simeq$ 1034 kms^{-1}. The derived height of the source region of the observed

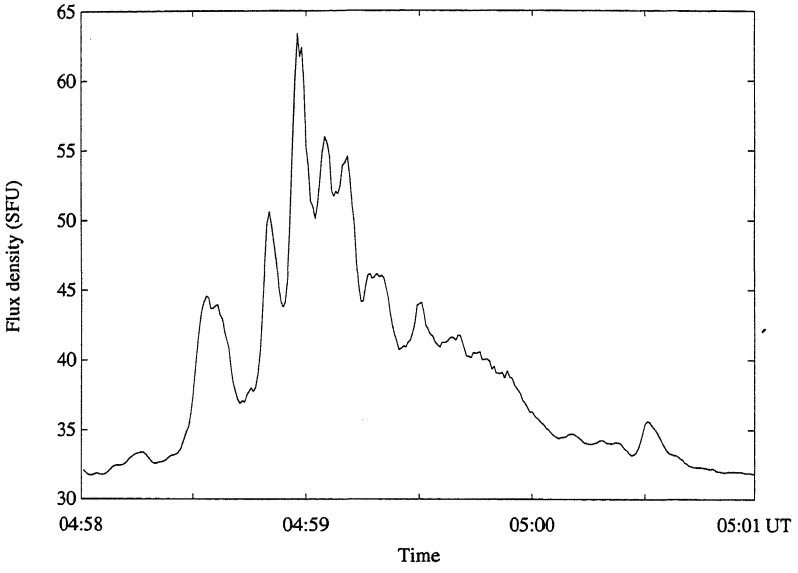


Figure 7. Whole Sun flux observed with the GRH on November 24, 2000 during the period 04:58-05:01 UT. One can notice clear quasi-periodicity in the emission from 04:58:30 to 04:59:30 UT.

quasi-periodic emission, and the magnetic field at the corresponding location (for emission in the fundamental mode) were $\simeq$ 0.23 $R_\odot$ and 6.3 G, respectively. The magnetic field for harmonic emission was found to be $\simeq$ 3.1 G. The quasi-periodicity in the radio emission was due to the modulation of the electron injection acceleration region by a coronal mass ejection (CME), launched prior to the onset of the radio burst and travelling through the solar atmosphere. Observations of this kind are considered to be significant since one can determine the coronal magnetic field in a straightforward manner without any assumption or extrapolation.

(R. Ramesh, C. Kathiravan, A. Satyanarayanan and E. Ebenezer).

Tracking the movement of a coronal mass ejection in the outer corona : Coronal mass ejections (CMEs) are large-scale magneto-plasma structures that erupt from the Sun and propagate through the interplanetary medium with speeds ranging from only a few km s^{-1} to nearly $\simeq$ 3000 km s^{-1}. They carry typically 10^{15} gm of coronal material. Most of the current observations of CMEs are from coronagraphs which detect them in Thompson scattered sunlight above its occulter. The latter generally covers both the solar disk as well as the low corona ($\leq$ 2 $R_\odot$. Observations from instruments such as the Large Angle and Spectroscopic Coronagraph (LASCO) onboard the Solar and Heliospheric Observatory (SOHO) have now revolutionized our perception and understanding of the solar eruptive events. However one needs non-coronagraphic data to obtain information on the early evolution of CMEs, in particular those directed along the Sun-Earth which occur far from the plane of the sky. The latter originate on the visible hemisphere of the Sun and appear as a 'halo' of expanding, circular brightening that completely surrounds or spans a large angle outside the occulting disk of the coronagraph. The Earthward-moving events are geophysically important, in the context of space-weather related phenomena such as geomagnetic storms. The near surface onset phase of a CME is important since its basic physical state is completely determined at its initiation. Its subsequent development during the transit through the heliosphere is just an evolutionary process. Measurements of CME properties in the lower corona are important for several reasons. Foremost among them is the general assumption that

CMEs have a constant speed behind the occulting disk of a coronagraph. This has often caused controversial results while comparing the CME onset with other solar activity signatures. 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

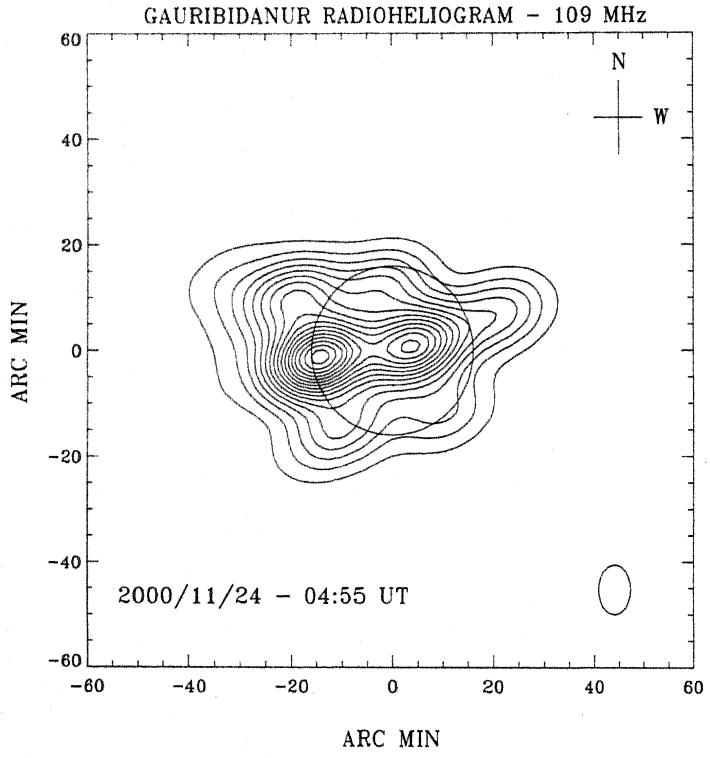


Figure 8. Radioheliogram obtained with the GRH on November 24, 2000 around 04:55 UT. The peak T_b is approx 4.18 x 10^6 K, and the contour interval is 0.27 x 10^6 K. The open circle at the center is the solar limb. The instrument beam is shown near the bottom right corner.

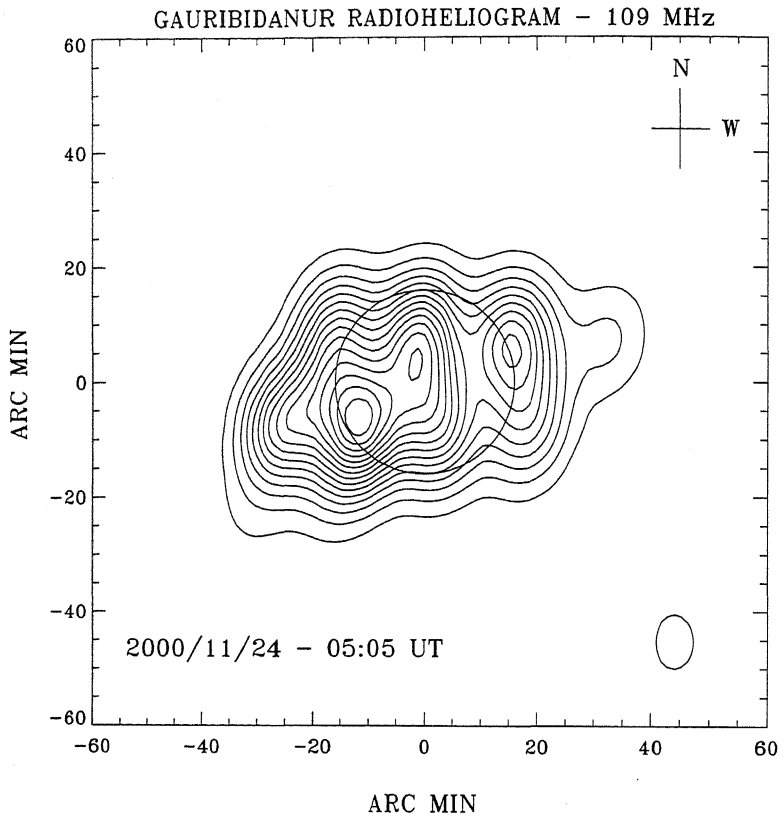


Figure 9. Same as Figure 8, but observed around 05:05 UT. The peak T_b is approx 6.08 x 10^6 K, and the contour interval is 0.34 x 10^6 K.

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. We used the GRH to image the radio counterpart of the 'halo' CME that occured on November 24, 2000 (Figures 8, 9, 10 & 11). The speed

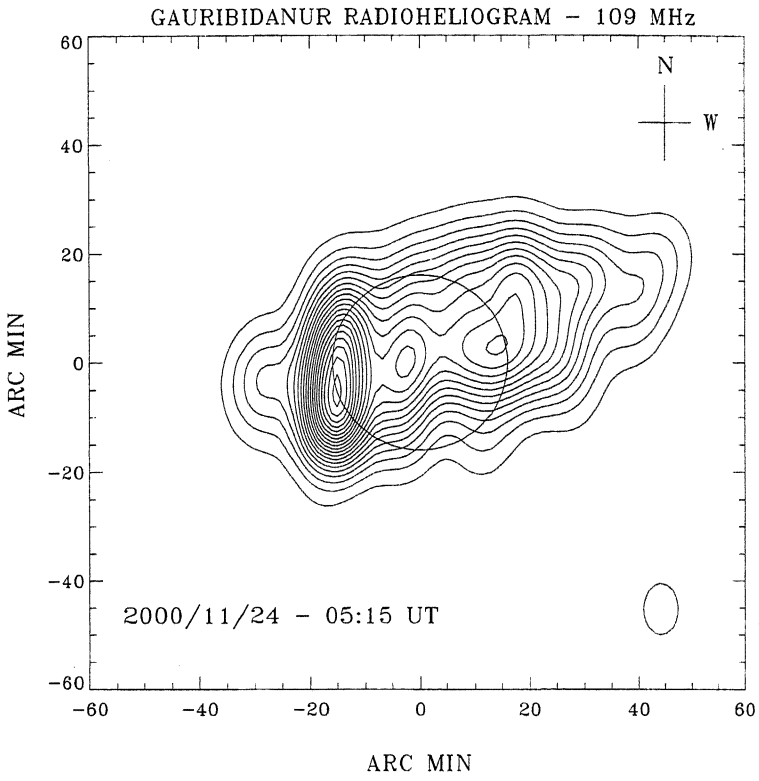


Figure 10. Same as Figure 8 & 9, but observed around 05:15 UT. The peak T_b is approx 6.1 x 10^6 K, and the contour interval is 0.39 x 10^6 K.

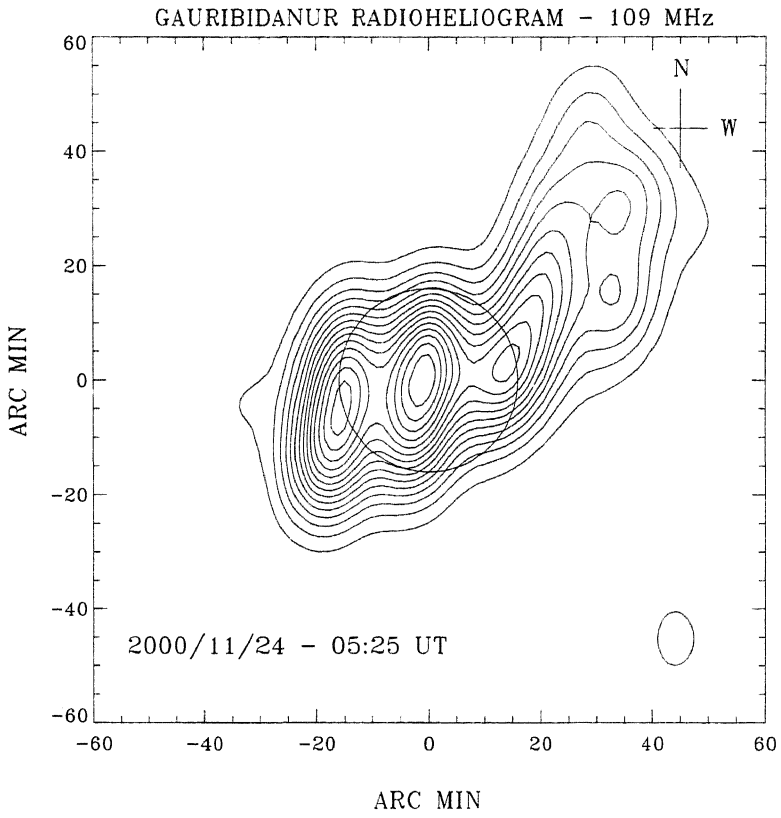


Figure 11. Same as Figure 8, 9 & 10, but observed around 05:25 UT. The peak T_b is approx 5.6 x 10^6 K, and the contour interval is 0.29 x 10^6 K.

and acceleration of the latter in the low corona were estimated in an independent manner from the displacement of the associated radio features,~and the average values are $\simeq$ 1136 $\pm$ 73 km s^{-1} and $\simeq$ 157 $\pm$ 121 m s^{-2}, respectively. The brightness temperature and electron density of the enhancement were found to be approx 1.92 x 10^5 K and 2.81 x 10^7 cm^{-3} at a distance of $\simeq$ 2.7 $R_\odot$ from the center of the Sun. We also computed the magnetic field strength of the enhancement at the above height, and the value is approx 0.86 G. The mass of the radio enhancement increased by a factor of ~ 2 during our observing period. Observations of this type are unique since only meter/decameter wavelength radio data telescopes can provide information about the history of a CME in the above height range.

(R.Ramesh,~C.Kathiravan and Ch.V.Sastry).

2. Solar system studies

Astrometry of the Galilean satellites from their mutual events : The mutual event light curves of the Galilean satellites of Jupiter of the campaign (PHEMU97) by L 'Institut de méchanique céleste et de calcul des éphémérides, Paris, were analyzed using the recently developed model which includes the intensity variations on the surface of satellites using the mosaics constructed by the teams at the U. S. Geological Survey from Voyager and Galileo imagery. Precise modelling of the light curves has enabled us to detect differences as small as 0.064" in the mean motion of Callisto compared to the Ephemerides.

(R. Vasundhara, J.-E. Arlot*, V. Lainey* and W. Thuillot*)

A re-analysis of the astrometry of the Galilean satellites from their mutual events during previous apparitions : The published impact parameters and the mid-time of events of the 1985 and 1991 mutual event series were derived without taking into account the albedo variations on their surfaces. As the importance of these effects has been realized only in recent years, systematic shifts in the event timings were earlier interpreted as real dynamical effects. All the light curves were re-analyzed by the new model and the residuals are found to improve. These improved positions will be used in the next version of the theory of the Galilean satellites.

(V. Lainey* and R. Vasundhara)

3. Solar-terrestrial physics and Geophysics

Equatorial effects of magnetospheric substorms : Recent studies provided unambiguous evidence for the presence of an ionospheric current component, in addition to those of distant currents in the dayside equatorial magnetic effects of magnetospheric substorms. It is not known, however, with what type of auroral disturbances and under what ambient global conditions the equatorial effects show up. We have addressed this question through an event-based study. The substorm activity studied is characterized by two onsets separated by 40 min: the first one occurred during steady southward interplanetary magnetic field (IMF) and steadily increasing cross-polar cap potential and enhanced energy input into the magnetosphere, while the second one occurred in close association with a northward transition of IMF and a rapid reduction of the polar cap potential and energy input into the magnetosphere. Earlier studies using multi-spacecraft data as well as ground-based optical, radar and magnetic recordings ascertained the first onset to be associated with a pseudo-breakup and the second onset with a 'true' breakup. Magnetometer recordings from a meridional network of stations in the Indian and Pacific sectors revealed the response of daytime equatorial H-field to the pseudo-breakup to be weak and not readily identifiable. In contrast, a distinct negative bay-like disturbance with an unambiguous dip equator enhancement prevailed in the H-field starting with the onset of the expansive phase of the fully developed substorm. This behavior indicative of a significant contribution of ionospheric currents to the negative H-field bay is seen both in the Indian and Pacific sectors covering the 12-16 LT region. The present case study thus suggests that a sudden and prominent reduction in the cross-polar cap potential at the substorm expansive phase is responsible for the prevalence of the ionospheric current component in the geomagnetic disturbance in the dayside equatorial region. It is also found for the first time that the amplitude of the negative H-field disturbance in the afternoon sector exhibits a marked hemisphere asymmetry at mid-latitudes: it is higher by a factor of about three in the summer hemisphere than in the winter hemisphere. The equatorial enhancement of the negative H-component disturbance is interpreted as the signature of the 'over-shielding' effect, namely, direct penetration of the perturbation component of the large-scale electric field associated with the rapid reduction in convection at the onset of the substorm expansion phase. The marked summer-winter asymmetry of the H-field disturbance at mid - latitudes is suggested as the outcome of the competing magnetic effects of field-aligned currents and polar origin DP2 currents.

(J. H. Sastri, Y. Kamide* and K. Yumoto*)

Geomagnetic response to sudden changes in magnetospheric convection : Rapid changes in magnetospheric convection induced by swift directional transitions of the interplanetary magnetic field (IMF) are known to lead to corresponding changes in the groundlevel geomagnetic field. But most of the previous work on this very topical but controversial subject had been limited to ionospheric convection and magnetic field variations in the polar caps.On the other hand, latitudinal profiles of the geomagnetic response spanning the subauroral region including the dip equator along different local time meridians give important information on the response and reconfiguration times of the geomagnetic field and also on the roles of the various current systems in the groundlevel magnetic effects. We have determined such latitudianl profiles for a few well-identified cases of sudden increases in magnetospheric convection due to sharp southward transition of IMF. The results on hand suggest that a significant role of not only the ionospheric current due to prompt penetration (*pp*) electric fields but also of the field-aligned currents that couple the large-scale

magnetospheric electric field to the polar ionosphere, in the subauroral magnetic effects on the dayside. Work on this topic is nearing completion.

(J. H. Sastri., Y. Kamide* and K. Yumoto*).

Development work : The digital fluxgate magnetometer (procured from Danish Meteorological Institute, DMI) had been installed at Kodaikanal in place of the aged La Cour Variometer. 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 with analog data.

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

Observational programmes: Regular data acquisition in the monitoring mode continued with the experimental facilities in Kodaikanal Observatory (IPS42 ionosonde, HF Doppler Radar and magnetometer.

(J. H. Sastri, J. V. S. V. Rao and staff of I & M section and STR Laboratory).

Microwave radiometric technique in remote sensing : As an important tool of atmospheric remote sensing, microwave radiometers are used for temperature profiling and vapor and liquid column measurements. In addition, ice water path can be retrieved using radiometer observations. In this review, the potential of radiometers is demonstrated by comparison with radiosonde data and observations using Global Positioning Systems (GPS).

Performance of various mathematical retrieval methods for water vapor and cloud liquid water profiles using microwave radiometer measurements are compared. These include regression methods, Newton iteration and neural networking. A specific case of temperature inversion near the ground and its retrieval by Philips-Twomay method is discussed.

(K.E. Rangarajan, B.A.Varghese, J.Vivekanandan*)

Earth system processes

1. Shear wave crustal structure of the Indian continent : Continuing Broad band seismograph data from Kodaikanal Observatory has led to further refinement of the deep crustal structure beneath the high grade granulite terrain of Kodaikanal and, in particular, of the azimuth and degree of anisotropy ingrained in olivine crystals aligned by processes of ductile shear. Analysis of Hanle broad band data from the station installed last year is currently in progress as well as that from the Leh broad band station set up last autumn (Figure 12). Scientific papers relating to the first are in press.

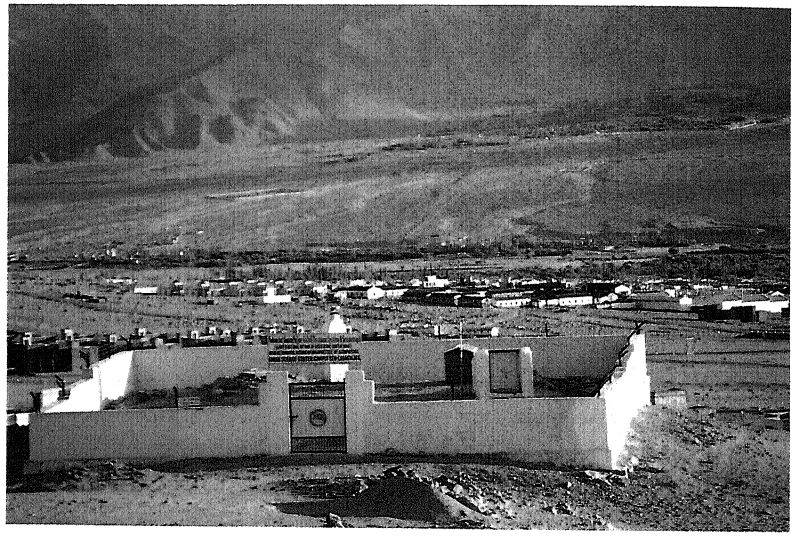


Figure 12.

2. A deformational mechanism of the trans-Himalayan Ladakh crust and equation of state of the crustal material : Rigorous analysis of data from 8 GPS campaign sites in Ladakh, the permanent GPS stations at Hanle set up earlier, and Leh (Figure 13) established last autumn, as a part of the DST national network, has yielded a rather low value (~3-4 mm/yr) for the

slip along the Karakoram fault, as against the hitherto accepted value of ~30 mm/yr determined by French scientists using offset geological features. Indeed, this 5 year long experiment was especially designed to constrain this number because it has profound implications as to the actual mechanism of crustal shortening in the region, thereby enabling one to determine the rheological constitutive equation of the material. The paper has been accepted for publication in the reputed journal of the Geological Society of America

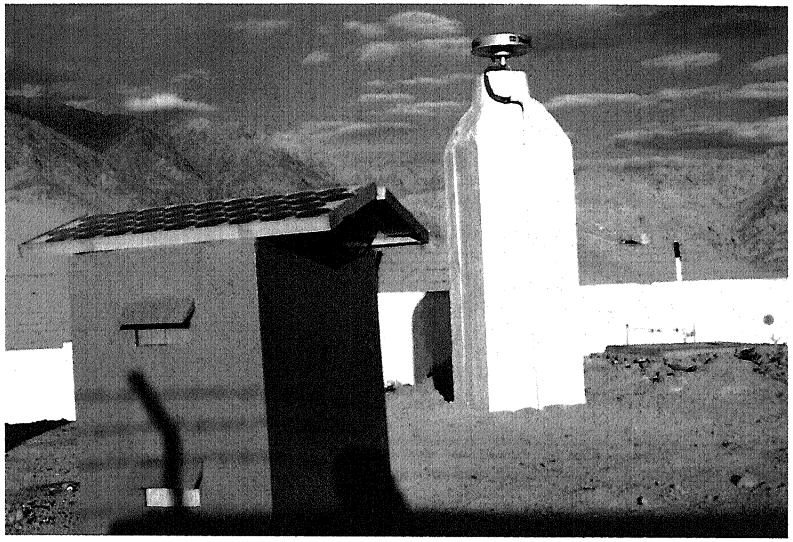


Figure 13.

3. Estimation of Precipitable Water Vapour (PWV) at the permanent GPS sites : Since PWV estimates constitute an important parameter in atmospheric modelling as well as in mesoshere- stratosphere research, an algorithm has been fine tuned for abstracting PWV estimates from GPS data being generated at the permanent GPS stations duly cleaned of ionospheric and dry atmosphere delays. Figure 14 shows estimated PWV above the Bangalore

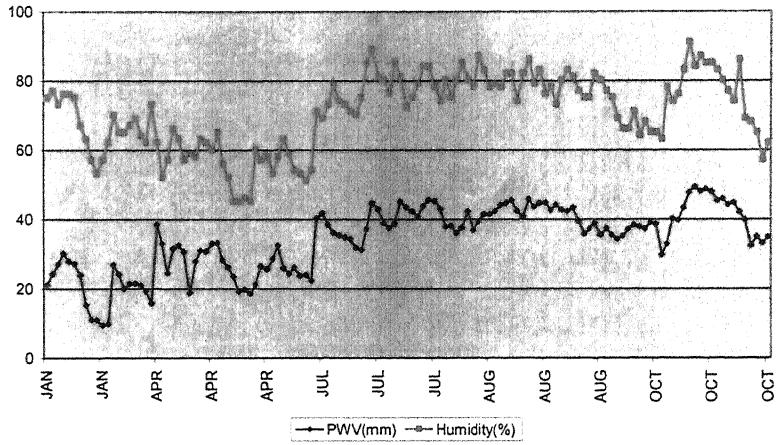


Figure 14.

GPS station in the campus of IISc, which has been extensively studied for validating the algorithm. Similar estimations for Leh, Hanle and Kodaikanal are in progress, and discussions with IMD have opened up the possibility of their using this development to operationalize regular estimations of PWV at all national GPS sites as well as some others to be specially established by them at critical sites.

(V.K. Gaur)

4. Stars and stellar systems

Optical spectroscopic and 2MASS measurements of Stephenson H_α stars : Optical spectroscopic observations for 52 objects from the list of H_α emission stars of Stephenson (1986) were made. Out of the six known T Tauri stars observed, five showed H_α in emission and in one (StHa 40) H_α changed from being in absorption to emission over a period of two years accompanied by photometric and spectral type variability. We confirm the T Tauri nature of one Stephenson object (StHa 48) on the basis of the presence of H_α and H_β in emission, Li Iλ 6708$ in absorption, infrared excess and X-ray emission. Among the 52 objects observed, there were other emission line objects: 1 Ke star, 1 BQ star, 2 galaxies and 2 Be stars. We obtain higher-resolution spectrum of StHa 62 showing permitted and forbidden lines in emission typical of BQ stars. Twenty five out of thirty newly observed objects failed to show H_α in emission. 2MASS observations for 112 StHa objects were analysed. We suggest three Stephenson objects (StHa 52, 125 and 129) to be YSOs on the basis of 2MASS, IRAS and ROSAT observations. These and all other known YSOs amongst StHa stars are found in regions of star forming clouds in Taurus, Orion and Ophiuchus. YSOs at high galactic latitudes in other parts of the sky are therefore rare.

(G. Maheswar, P. Manoj and H. C. Bhatt)

Kinematics of Vega-like stars and the temporal evolution of their dust disks : From Hipparcos measurements of the parallaxes and proper motions of Vega-like stars we have evaluated the plane-of-the-sky velocities of these objects. About 400 stars were studied. We have used the velocity dispersion as an age indicator to constrain the ages of this large sample of Vega-like stars in order to study the temporal evolution of the dust disks around them. We find a strong correlation between fractional dust luminosity ($f_d \equiv L_{dust} / L_{star}$), obtained from the IRAS measurements, and velocity dispersion of Vega-like stars. Fractional dust luminosity is found to drop off with increasing stellar age according to the power law $f_d \propto (age)^{-2.38}$. Ages of these main sequence dusty systems range from a few times 10^7 yr to a *Gyr*. Further, we show that the correlation between f_d and velocity dispersion extends to pre-main sequence Herbig Ae/Be stars also.

(P. Manoj and H. C. Bhatt)

Spectroscopic studies of RV Tauri stars : We have completed an extensive analysis of a large sample of field RV stars showing large radial velocities (RV C stars). These objects show chemical anomalies caused by selective removal of condensable elements into the grains. Hitherto this abundance anomaly was seen only in highly evolved post-AGB stars with strong infrared fluxes indicating the presence of dust envelopes caused by considerable mass-loss through stellar wind. In RV Tauris this phenomenon was reported earlier only in RVB members. Detection of this chemical peculiarity in stars with no indication of dust envelopes and high radial velocity shows that stellar wind might not be the sole cause of the above mentioned chemical peculiarity and one must also consider circumbinary envelopes as possible site where the refractory elements could get locked-up into the grains.

(Sunetra Giridhar, David L Lambert* and G. Gonzalez*)

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 parallaxes and proper-motions

available from Hipparcos data. The new calibration predicts absolute magnitudes with an accuracy of ± 0.4 mag. This calibration has been applied to a sample of evolved objects to be able to locate their positions in the H-R diagram.

(A.Arellano Ferro*, Sunetra Giridhar and E. Rojo Arellano*)

A High-resolution Spectrum of the R CrB Star V2552 Ophiuchi : Photometry and low-resolution spectroscopy have added V2552 Oph to the rare class of R Coronae Borealis variables. We confirm this classification of V2552 Oph through a comparison of our high-resolution optical spectrum of this star and that of R CrB and other F-type members of the class. We show that V2552 Oph most closely resembles Y Mus and FH Sct, stars in which Sr, Y, and Zr are enhanced.

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

Abundances of neutron-capture elements in the hot extreme-helium stars V1920 Cygni and HD 124448[1]: Analysis of *HST* STIS ultraviolet spectra of two hot extreme helium stars (EHes) : V1920 Cyg and HD 124448 provide the first measurements of abundances of neutron-capture elements for EHes. Although the two stars have similar abundances for elements up through the iron-group, they differ strikingly in their abundances of heavier elements : V1920Cyg is enriched by a factor of 30 in light neutron-capture elements (Y/Fe, Zr/Fe) relative to HD 124448. These differences in abundances of neutron-capture elements among EHes mirrors that exhibited by the R CrB stars, and is evidence supporting the view that there is an evolutionary connection between these two groups of hydrogen-deficient stars. Also, the abundances of Y and Zr in V1920 Cyg provide evidence that at least one EHe star went through a *s*-process synthesis episode in its earlier evolution.

(Gajendra Pandey, David L. Lambert*, N. Kameswara Rao and C. Simon Jeferry*)

The 2002 Outburst of the Recurrent Nova IM Normae : 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 light curve of the recent outburst indicates it to be a slow nova. The spectral development of the 2002 outburst was monitored from VBO, during the early phases as well as during the late nebular phase, about 400 days since the outburst maximum. The early spectral development is similar to the 'hybrid' classical novae, where the nova changes from an initial 'Fe II' type to the 'He/N' type. The nebular phase spectrum shows a very weak continuum with few emission lines. The light curve and the early spectral development of IM Nor resembles that of T Pyx. IM Nor thus belongs to the T Pyx class of recurrent novae. The accreting white dwarf in these systems has a mass lower than those in the other RNe systems, and hence are not potential progenitors of supernovae of type Ia. The nova was also observed during the early and late nebular phases. High resolution spectra were obtained during the early nebular phase in September 2002 from Argentina, in collaboration with E. Brandi, while low resolution spectrum was obtained from VBO in February and March 2003 during the late nebular phase.

(G.C. Anupama)

The nebular shell of the old nova GK Persei : Low frequency radio observations in the 327 MHz, 610 MHz and 1440 MHz bands have been obtained using the Giant Metre-Wave Telescope. Images through narrow band filters centered around the Hα+[NII] and [OIII], 5007 Å lines were also obtained using the HFOSC on the 2-m HCT. These data will be used to study the nebular remnant of the nova as well its environs.

(G.C. Anupama, N.G. Kantharia*)

Supernova SN 2002ap : Spectra of the supernova SN 2002ap, were obtained from VBO, during its early phases, 1–3 days before maximum and 3 days after maximum. The spectra show broad features, with

extremely high velocities similar to the type Ic hypernovae SN 1998bw and SN1997ef. The photospheric velocity estimated using the Si II 6347, 6371 Å (6355 Å) absorption minimum decreased from a value of 21,360 ± 2000 km s^{-1}, 6.7 days since explosion to 10,740 ± 1500 km s^{-1} 12.69 days since explosion.

The photometric observations in the *U BV RI* bands in the early decline phase from State Observatory, Nainital and in the late decline from IAO, Hanle, indicate a flattening in the light curve about 30 days past the *B* maximum. The flux decline rates before flattening are 0.127 ± 0.005, 0.082 ± 0.001, 0.074 ± 0.001, 0.062 ± 0.001 and 0.040 ± 0.001 mag day^{-1} in *U*, *B*, *V*, R_c and I_c passbands respectively, while the corresponding values after flattening are about 0.02 mag day^{-1} in all the passbands. The absolute *V* magnitude of SN 2002ap at maximum is $M_V = -17.2$ mag, which is comparable to that of the type Ic hypernova SN 1997ef, but fainter than that of the type Ic hypernova SN 1998bw. The peak luminosity indicates an ejection of ~ 0.06 $M_\odot$ ^{56}Ni mass.

Photometry of SN 2002ap during its nebular phase was done from IAO, Hanle as well as State Observatory, Nainital. Nebular spectra were also obtained from IAO using the HFOSC on the 2-m HCT. Detailed analyses of the data are under progress.

(S.B. Pandey*, G.C. Anupama, R. Sagar*, D. Bhattacharya*, D.K. Sahu and J.C. Pandey*)

SN 2002hu : The type Ia supernova SN 2002hu was monitored in the UBVRI bands from IAO, Hanle, using the HFOSC instrument on the 2m HCT.

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

Symbiotic stars : The project on long-term monitoring of symbiotic stars in the optical, initiated in 1999 is continuing. The results of the long term (1999–2002) monitoring of the spectrum of the symbiotic stars EG And, AX Per, BX Mon, RX Pup, RW Hya, AS 210, and StHα 149 from VBO were presented at the Euroconference on Symbiotic Stars. The variablity in the continuum and emission lines were studied, as well as the secondary spectral types estimated. The optical spectra will be combined with data in other wavelength regions to study the various problems posed by the activity of these binaries. In addition to the optical spectra that have been obtained from VBO, observations of symbiotic novae PU Vul, RX Pup, HM Sge and R Aqr have been obtained in the 1210 MHz and the 610 MHz bands have also been obtained using the GMRT. These data will be used to study the radio flux at the low-frequency regions as well as study the radio nebula around the symbiotic novae. It is proposed to obtain images of the nebula through emission lines in the optical region. The combined radio and optical data will give information about the physical conditions in the nebula.

(G.C. Anupama, U.S. Kamath, J. Mikoajewska* and N.G. Kantharia*)

Near-infrared spectra of symbiotic stars : Symbiotic stars are binary systems consisting of a hot star, a cool red giant and a surrounding nebulosity. Most of the near-infrared spectra of symbiotic stars in existing literature have been obtained at low-to-moderate resolutions, resulting in the blending of many interesting spectral features such as the CO bands. Although isolated cases of higher resolution studies exist, the sample of such stars is small. In order to overcome this deficiency, a programme of obtaining medium-resolution (R = 1000) near-infrared spectra of symbiotic and related stars has been started in order to obtain a homogeneous set of data for studying the red giant component in these systems. Spectra of BD Cam, EG And, UV Aur, StHα 55, CD –28° 3719, and NQ Gem in the 1-2.5μ region have been obtained so far and were presented at the Euroconference on Symbiotic Stars. The observations have been carried out at the 1.2m telescope of Mt. Abu IR Observatory. The data will be compared with theoretical models to obtain a better understanding of these systems.

(U. S. Kamath, N. M. Ashok*, G. C. Anupama and J. Mikoajewska*)

Optical spectroscopy of GK Persei : The old nova GK Persei is well-known for exhibiting dwarf-nova outbursts since 1948. It has a quasiperiodic outburst interval ranging from 900 to 1340 days. However, the theoretical models cannot satisfactorily explain some features of the spectra at minimum and maximum brightness. The accretion-disc heating mechanism is thus still elusive. Optical spectra of GK Per have been obtained using the Boller & Chivens and OMR spectrographs at the VBT, covering two outbursts in 1996 and 1999, and the preceding and following quiescent phases. Varying emission line strengths even at quiescence, splitting of the H-alpha profile in the 1995 quiescent spectrum, flat-topped profile with structure of the He I lines are some of the interesting features seen. Changes in the slope of the continuum reveal the status of the underlying activity of the accretion disc. There is a considerable increase in the equivalent width of the He II lines during outburst compared to the quiescence value. We continue to monitor this interesting star for more unusual activity. Such long-term studies have the potential to refine the outburst models of GK Persei.

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

Lithium and rotation in Pop I stars : Lithium abundances have been determined in 127 F and G Pop I stars based on new measurements of the equivalent width of the 6707Å Li I line from their high resolution CCD spectra obtained with the coude echelle spectrograph on the 102cm telescope at VBO. Distances and absolute magnitudes of these stars have been obtained from the Hipparcos Catalogue and their masses and ages derived, enabling us to investigate the behaviour of lithium as a function of these parameters. A large spread in the Li abundances is found at any given effective temperature especially in the already spun down late F and early G stars. This spread persists even if the 'Li-dip' stars that have evolved from the main sequence temperature interval 6500-6800 K are excluded. Stars in the mass range up to 2 $M/M_{\odot}$ when divided into three metallicity groups show a linear correlation between Li abundance and mass, albeit with a large dispersion around it which is not fully accounted for by age either. The large depletions and the observed spread in Li are in contrast to the predictions of the standard stellar model calculations and suggest that they are aided by non-standard processes depending upon variables besides mass, age and metallicity. The present study was undertaken to examine, in particular, the effects of one such variable, i.e. rotation on the depletion of Li. The observed abundances seem to be dictated by the rotational history of the star. However, it is noted that even this interpretation is subject to the inherent limitation in the measurement of the observed Li EQW for large rotational velocities.

(Sushma Mallik, M. Parthasarathy and A.K. Pati)

Lithium in stars of alpha Per cluster : We have begun a study of Li in the α Persei cluster based on the data of 80 stars observed by them at R ~ 50,000 with the echelle spectrographs at the Kitt Peak and McDonald Observatories. α Per is a very young cluster, about 50 Myr old, so we would expect the stars to retain their initial Li over much of the temperature range. Depending upon the relative timescales of rotational braking for different stars and if the star formation within the α Per cluster has occurred over a finite period, its stars would have a range of rotational velocities. The K dwarfs having barely arrived on the MS are expected to be rotating rapidly but many of them have already spun down. We are curious to know how Li and rotation are linked and whether α Per fits in with the picture already known of other clusters of different ages and metallicities. For rapidly rotating stars in the α Per cluster, it was not possible to determine T_{eff} spectroscopically and one had to resort to photometry and colour-temperature calibrations. This was further complicated because we had to also correct for reddening claimed to be variable across the cluster. Since the H_{β} flux is a reddening-free temperature indicator, we computed H_{β} temperature for all the stars of α Per for which both H_{β} and UVBY photometry exist (the latter being particularly sensitive to the temperature for F and G dwarfs) and used the colour-temperature calibration to obtain reddening estimates for all these stars. We plotted these in RA and Dec as also our program stars to confirm they are uniformly spread across the cluster. Then we applied the reddening correction to the (V–I) colours we have for our stars to obtain temperatures. It is a non-

trivial exercise to make sure of our choice of temperature for each star. This is under further scrutiny before we pass judgement on the Li patterns in the cluster

(Sushma Mallik, S. Balachandran* and D.L. Lambert*)

Planetary nebulae : The planetary nebula Me 2-1 is being modelled with the use of CLOUDY and observations in the wavelength range of ultraviolet to radio. New observations from Infrared Space Observatory and recalibrated NEWSIPS data of International Ultraviolet Explorer are being analyzed along with archival Hubble Space Telescope images for this purpose. Questions aimed at unravelling the physical parameters of the central star as well as the composition of the nebula are taken up in a detailed way, thus making the research unprecedented in many ways.

(R.Surendiranath, P.Garcia Lario*, and S.R.Pottasch*)

Exobiology : If exoplanets come, can exobiology be far behind? With the discovery of about 100 exoplanets, this question assumes tremendous importance since it has high stakes not only for astrophysics but all of humanity. The SETI programme is used to search Extraterrestrial intelligence from the observations made at 1420 MHz using the Arecibo Radio Telescope. The analysis is carried out in an automated mode. More than 100 work-units (ie. sets of data) have been analyzed during the reporting period and the search is going on. The Search for Extraterrestrial Intelligence (SETI) looks at targets all over the sky in search of an alien signal in addition to the known exoplanets.

(R. Surendiranath)

A possible warp in the Large Magellanic Cloud : The LMC, SMC and the Milky Way are known to have experienced close encounters. The interaction of the Milky Way with the Magellanic Clouds could result in tidal forces which could alter the structure of the Clouds. DENIS and 2MASS survey of the LMC found evidences for tidal forces acting on the LMC. We look for further evidence for the interaction, like the presence of a warp, by studying the geometrical structure of the LMC disk. We use the brightness of core helium-burning red clump stars in the central regions of the LMC disk. The difference in the mean magnitudes of the de-reddened red clump stars is used as differential distance indicator. The preliminary results of such a study using OGLE II data indicates that the western part of the central LMC and north-western regions are located closer by more than 2.5 Kpc. This deviation from the general orientation of the disk could be considered as a warp. A warp of similar magnitude is reported for the south-western part of LMC (Olsen & Salyk 2002). The presence of a warp and its orientation towards the Galaxy indicates that this could be a signature of the tidal interaction between the LMC and our Galaxy.

(Annapurni Subramaniam)

Local stellar population of slow nova regions in the SMC : Population synthesis models of the statistics and properties of Galactic CVs and extragalactic novae indicate that the rate of formation of CVs, the nova rate and the distribution of novae over speed classes depend on the star formation history of the Galaxy. It was also suggested that the fast novae belong to the disk population, whereas the slow novae belong to the bulge population.

Most of the novae detected in the SMC are located in the central region and this could be an observational bias. Both the identified slow novae are very close to the center of the SMC. This is in contrast with the LMC, where the slow novae are detected in the outer regions. The local stellar population around two slow novae is studied using the photometric data of the OGLE II catalogue of the SMC. The ages of the stellar population in these regions are estimated by fitting isochrones to the CMDs. The local stellar population around both the slow novae in SMC show that the slow nova progenitor is likely to fall in the age range of 1 – 10 Gyr. A similar result was obtained for one slow nova in LMC. This indicates that the slow nova progenitor could

belong to an older population, when compared to the progenitor of the fast and moderately fast novae (1 – 3.2 Gyr).

(Annapurni Subramaniam)

The afterglow and the host galaxy of GRB 011211 : In this paper multi-band photometry of the afterglow of the x-ray rich, long-duration Gamma Ray Burst GRB 011211 is presented. The data in B, V, R & I bands from VBO-1m, 2.34m VBT has been combined with those obtained from Nordic Optical Telescope (NOT) at La Palma, Danish 1.5m and 3.5m New Technology Telescope (NTT) at La Silla, 1m- Sampurnananda Telescope at Naini Tal, 8.2m Very Large Telescope (VLT) as well as Hubble Space Telescope (HST) obtained 14, 26, 32 & 59 days after the burst. The broken power-law fitted to the R-band data shows a break in the light curve after 1.56 ± 0.02 days after the burst with slopes $\alpha_1 = -0.95 \pm 0.02$ and $\alpha_2 = -2.11 \pm 0.07$. The Spectral Energy Distribution (SED) is fitted with a power-law of index $\beta = -0.56 \pm 0.19$. The X-ray data results in a decay index of $\alpha_x = -1.62 \pm 0.36$ and spectral index $\beta_x = -1.21$. The afterglow evolution is consistent with a jet expanding into an external medium with constant density.

(P. Jakobsson* J Hjorth*, SG. Bhargavi, R. Cowsik; 22 authors)

Observing the Gamma-Ray burst remnants : Following the predictions of Perna, Reymond & Loeb (2000) we have proposed an observational program to search for the GRB remnants in nearby galaxies using the telescopes of Indian Institute of Astrophysics, Bangalore. We discuss the strategies, facilities and feasibilities of observations. Such a study would contribute to various aspects viz. progenitors, burst environment, GRB rate and so on.

(SG Bhargavi, R. Cowsik and R. Perna*)

GRB 021004 : The optical afterglow of the bright, long GRB event GRB 021004 was monitored in the *BVRI* bands from IAO, Hanle using the HFOSC instrument on the 2m HCT. Low resolution spectra of the afterglow were also obtained. These data were combined with the *BVRI* photometric observations from State Observatory,

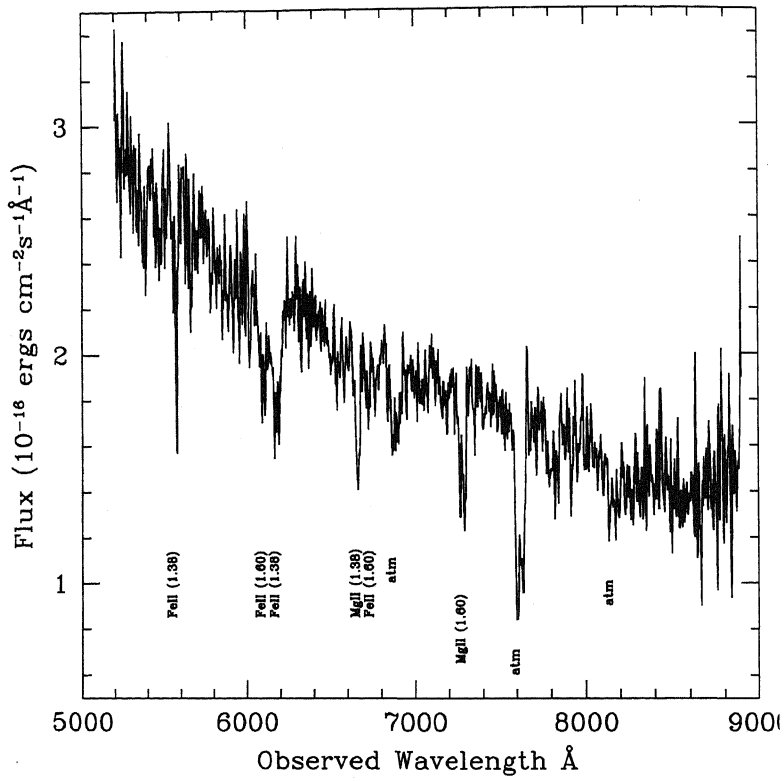


Figure 15. Optical spectrum of the GRB 0021004 OA corrected for E(*B-V*) = 0.20 mag in the wavelength range 5500–9000 Å. The absorption lines are marked along with the estimated redshift value.

Nainital to obtain a good temporal coverage of the light curve. Flux decay of the afterglow shows a very uncommon variation relative to other well-observed GRBs. Rapid light variations, especially during early times ($\Delta t < 2$ days) is superposed on an underlying broken power law decay typical of a jetted afterglow.

The spectrum shows a blue continuum with superposed absorption features. The absorption systems are identified with two intervening metal-line systems at z = 1.38 and 1.60. A single power law $F_\nu \propto \nu^{-\beta}$ was found to fit the continuum. A chi-squared minimization for the power law yields an index of $\beta = 0.59 \pm 0.02$.

Multiwavelength observations indicate the association of this GRB with a star forming region, supporting the case for a collapsar origin of long duration GRBs.

(S.B. Pandey*, D.K. Sahu, L.Resmi*, R. Sagar*, G.C. Anupama, D. Bhattacharya*, V. Mohan*, T.P. Prabhu, B.C. Bhatt, J.C. Pandey*, Padmakar Parihar and A.J. Castro-Tirado*)

GRB 021211 : The optical afterglow of the GRB event GRB 021211 was observed from IAO, Hanle, using the HFSOC instrument on the 2m HCT. The data from IAO were combined with the photometric observations from State Observatory, Nainital. Flux decay of the GRB 021211 afterglow in *R* passband is characterized by a power-law of overall slope 1.1 ± 0.1 during 12 min to 30 days after the burst. The evolution of the spectral energy distribution over the first few hours after the burst indicates that the cooling frequency ν_c passed through the optical-NIR band during this time. The observed redshift and fluence values imply an isotropic emission of gamma-ray energy $E_{iso,\,\gamma} = 1.02 \times 10^{52}$ erg at a cosmological distance of about 7.2 ~ Gpc after applying the cosmological K-correction. The prompt burst emission of the optical afterglow shows a flux decay similar to that of GRB 990123. However, GRB 021211 is intrinsically fainter than GRB 990123 by atleast a factor of 4, and was detected only due to prompt, early follow-up. But for the prompt observations, it would have been classified as a "dark GRB" as it was fainter than $R = 23$ after 1 day and in general, the usual follow-up observations do not go that deep. It thus appears that GRB 021211 is the first example of an "optically dim" burst for which early time observations are available.It is thus likely that the optically "dark GRBs" could just be "optically dim" afterglows with the reason behind their non-detection being not only due to the high redshift and extinction due to host galaxy but also due to the OA being much fainter than those observed to date.

(S.B. Pandey*, G.C. Anupama, R. Sagar*, D. Bhattacharya*, A.J. Castro-Tirado*, D.K. Sahu, Padmakar Parihar and T.P. Prabhu)

GRB 030226 and GRB 030329 : BVRI photometry of the optical afterglows of the GRB events GRB 030226 and GRB 030329 were performed using the 2-m HCT. The HCT data are being combined with photometry from State Observatory, Nainital for a detailed study of these objects.

(HCT team, State Observatory, Nainital Team)

Ultra Violet Imaging Telescope (UVIT) – Science* : Some of the significant ares of astronomy that would be persued by UVIT, one of the payloads on the proposed Indian multiwavelength astronomy satellite ASTROSAT, is described. Some of the considerations and uniques of the system are highlighted. UVIT aims to provide flux calibrated images of the sky at a spatial resolution of about a second of arc in the wavelength range 1250 to 3200Å along with optical bands.

(N. Kameswara Rao)

5. *Theoretical astrophysics and cosmology*

Radio emission altitudes in pulsars : Using the equation for a dipole magnetic field line $r = r_e \sin^2\theta$, we have constructed the field line geometry of pulsar magnetic field. Figure 16 shows the 3 dimensional magnetic field ($r_e = 1$) inclined through an angle of $\alpha = 30^\circ$ with respect to the rotation axis ($\hat{z}$). We can find the polar angle θ at which the curvature vector to the field line becomes perpendicular to $\hat{z}$, and derive the shape of polar cap for different inclination angles α, as shown in Figure 17. If we assume the particle emission is relativistically beamed in the direction of tangent to the field line then the line-of-sight must align with the tangent for receiving the radiation. So by knowing the field line constant r_e from Figure 17, we can estimate the emission height for last open field lines. In Figure 18, we have plotted the

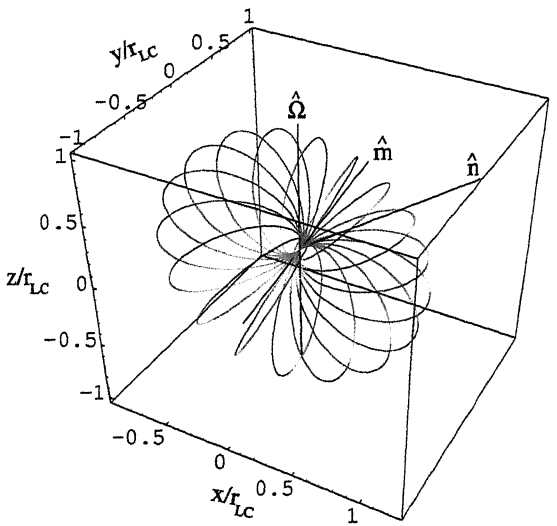


Figure 16. 3D dipole magnetic field for $r_e = 1$, inclined through an angle $\alpha = 30^\circ$ with respect to the rotation axis ($\hat{z}$)

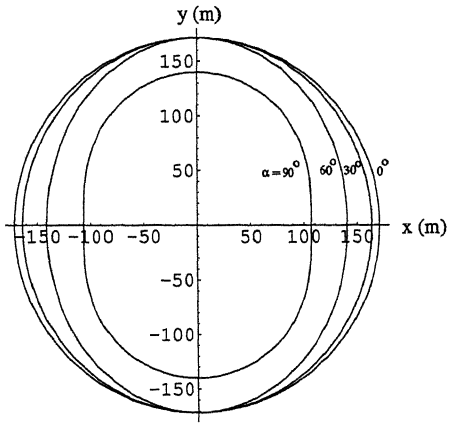


Figure 17. Shapes of polar cap of the pulsar with period p = 0.714 s at different inclination angles α.

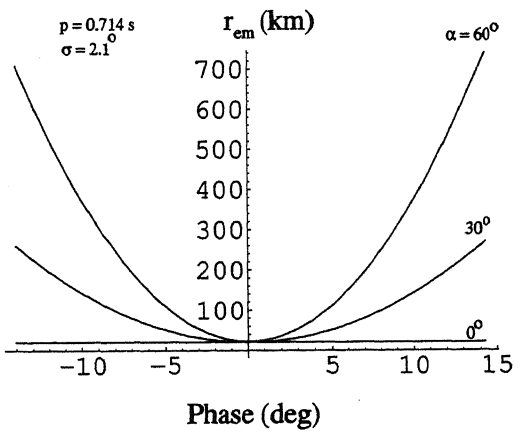


Figure 18. Emission heights for the last open field lines of a pulsar with period p = 0.714 s at different inclination angles α.

emission heights with respect to rotation phase at different values of period p, α and line-of-sight impact angle σ. It shows the pulse center (core) emission comes from lower heights while outer (conal) emission comes from higher heights, in agreement with results of PSR B0329+54 published by Gangadhara and Gupta (2001).

R. T. Gangadhara)

Radio emission by particles accelerated in pulsar magnetosphere : We present a relativistic model of pulsar radio emission by plasma accelerated along the rotating magnetic field lines projected on to a 2-D plane perpendicular to the rotation axis. We have derived the expression for the trajectory of a particle, and estimated the spectrum of radio emission by the plasma bunches. We used the parameters given in the paper by Peyman and Gangadhara (2002). Further the analytical expressions for the Stokes parameters are obtained, and compared to their values with the observed profiles. The one sense of circular polarisation, observed in many pulsars, can be explained in the light of our model.

(R. M. C. Thomas and R. T. Gangadhara)

Plasma acceleration in pulsar magnetosphere : We present a relativistic model for the centrifugal acceleration of plasma bunches and the coherent radio emission in pulsar magnetosphere. We find that rotation broadens the width of leading component compared to the width of trailing component. We explain this difference in the component widths by using the nested cone emission geometry. We estimate the effect of pulsar spin on the Stokes parameters, and find that 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. Our simulation shows that changing the sign of the impact parameter changes the sense of circular polarization as well as the swing of polarization angle.

(R. T. Gangadhara and V. Krishan)

The polarized line formation in solar / stellar atmospheres : The work on the theory of polarized line formation in Solar/ Stellar atmospheres continues. The work on partial redistribution (PRD) in weak magnetic field Hanle effect is completed, and published. To date this work represents the most advanced, and sophisticated work on polarized PRD line transfer calculation. Some long standing questions like the validity and correctness of using Angle Averaged functions in the place of Angle dependent PRD functions, were once for all settled, with the 5 papers published in last 2 years on this topic.

In the 6th paper of the well known PALI (Polarized Approximate Lambda Iteration) series published by Nagendra and collaborators, a Generalized core-wing method (named GPALI) for Hanle Effect with PRD and the collisions was developed (D.M. Fluri, K.N. Nagendra, and H. Frisch: 2002a, A&A 400, 303-320). An Angle averaged version of the well known Bommier's redistribution functions were used in that work. An Angle dependent analogue of this work would be a theoretician's delight! - the numerical method would be highly sophisticated and complex, but almost essential for any state of the art modelling of the Solar Hanle polarization data on spectral lines. In the absence of such general method, we have solved the concerned problem, under the next best approach - namely a perturbative solution. An account of this Method is given in Nagendra, Frisch, & Faurobert (2002b, A&A 395, 305-320). The importance of Angle Dependent Hanle redistribution in the analysis of Solar Weak Magnetic fields, is emphasized in this paper.

Several theoretical questions, and especially the classical approximation of handling the actual Hanle effect through a combination of Hanle scattering in the line core, and non-magnetic Rayleigh scattering in the line wings, is

examined in Faurobert, Frisch, & Nagendra (2002c, ASP Conf. Ser. Vol. 248, 145-148).

The question of "symmetry characteristics" and peculiarities of the Angle Dependent (AD) Hanle scattering partial redistribution are addressed in another paper by Frisch, Nagendra, & Faurobert (2002d, ASP Conf. Ser. Vol. 236, 197-204). It is shown that symmetries are satisfied, by considering frequency integration over the whole bandwidth of the line, unlike Rayleigh scattering mechanism, where such symmetries are satisfied differentially at each frequency.

(K. N. Nagendra)

Steady parts of magnetic field and rotational velocity field structures in the atmosphere of late type stars : The aim of the present study is to understand the observed polarization of main sequence late type stars. It is expected that polarization may be mainly due to the large scale ordered magnetic field structures evolved from their proto stellar phases. Most of the models which explain the polarization properties assume the dipole or quadrupole field structures derived from the current-free approximations. Contrary to the current free approximation, currents are distributed everywhere in the stellar atmosphere. The current-free approximation has also the following serious difficulty in case of strong magnetic fields in the stellar atmosphere : the evolution of ordered velocity field structures like angular velocity and meridional circulations are decoupled from the effects due to magnetic fields. Using MHD equations, with reasonable assumptions and approximations, we solve consistently the velocity and magnetic field structures. In this way, the present study has the following advantage compared to the previous studies which use current-free approximations : the large scale ordered velocity fields (angular velocity and meridional circulations) and magnetic field structures of the stellar atmosphere can be obtained from the observed properties of the polarizations. The approach of the problem and the preliminary results are as follows.

In the framework of axisymmetric and incompressible plasma, Chandrasekhar's MHD equations are used for solving the steady parts of the poloidal component of the magnetic field and rotational velocity field structures in the atmosphere of the late type stars. It is assumed that the large-scale meridional circulations in the stellar atmosphere are absent. Since most of the late type stars have turbulent atmospheres, we use a reasonable assumption that the constants of eddy viscosity and turbulent diffusivity are very large. Important results from the simplified MHD equations are : (i) Ferraro's law of isorotation and, (ii) analytical solutions of magnetic and rotational velocity field structures which have unknown parameters to be solved from the boundary conditions.

Following Hiremath (*BASI*, **29**, 169, 2001), and using appropriate boundary conditions at the stellar surface and at the end of the stellar atmosphere, we solve the rotational velocity field structure in the atmosphere. Following similar approach (Hiremath and Gokhale, (*Ap J*, **448**, 437, 1995) in deriving steady part of the poloidal magnetic field structure in the solar interior, we determine atmospheric magnetic field structure. For the sake of academic interest, we assume that intensity of radiation in the stellar atmosphere is isotropically distributed. We analytically derive the line of sight component of the average magnetic field in the atmosphere of a late type star. We find that the line of sight component of the average magnetic field depends upon the strengths of the different components of the magnetic field structure, average density and thickness of the stellar atmosphere.

(K. M. Hiremath)

Cosmological formation of black holes : Supermassive disks are thought to be precursors of supermassive black holes that are believed to

power quasars and exist at centers of galaxies. Formation scenarios of such disks were studied and it is argued that gas dynamical schemes are favourable compared to stellar dynamical schemes which could however be important feeding mechanisms for the growth of the black hole. We calculated a new self-similar model of a collapse of a self-gravitating disk due to radiation induced stresses applicable to two different situations of radiative viscosity and Compton drag. The collapse timescale purely due to radiative viscosity was found to be a fraction of Hubble time, $\tau_\gamma \sim \sigma_T$ C $(m_p G)$ (L_{edd}/ L) 6 x 10^9 yrs is ineffective and probably magnetic fields play an important role before general relativistic effects take over. We produced a model of self-gravitating disk collapsing due to Compton drag by the Cosmic Microwave Background which is found to be effective at redshifts $1400 > z_{gsim} \gtrsim 100$. It is proposed that the small $\lesssim 10^5 M_\odot$ objects that form by this mechanism by $z \sim 20$ can merge and coalesce by dynamical friction to form the high redshift quasars seen. Supermassive stars which are systems (and could be end products of a supermassive disk phase) en route to the final collapse was also briefly reviewed (Mangalam 2003). We are planning to incorporate GR effects in models above which is important during the advanced stages of collapse to a black hole.

(A. Mangalam)

Astrophysical magnetic fields: limits on dynamo generated fields by magnetic helicity : Magnetic fields correlated on kiloparsec scales are seen in spiral galaxies. The origin could be due to amplification of small scale seed fields by a turbulent dynamo. Helicity conservation imposes constraints on dynamo action and in collaboration with K. Subramanian* (IUCAA), I am studying the minimal field strength of the large scale magnetic field that could arise despite the constraint. The calculation of helicity is technically complicated because of open boundaries and the usual form for the MHD invariant needs to be modified to take this into account. The general formalism developed here has several other applications including the solar dynamo.

(A. Mangalam)

Stellar dynamics : Stellar cusps around black holes : Black holes in the centres of galaxies grow by swallowing of stars. One of signatures of the process is the stellar cusp which has a certain observed profile. More precise observations are underway and models are required to understand the process. Stellar orbits diffuse by two-body relaxation toward lower angular momentum orbits until they enter a small loss-cone. I am studying this process of stellar capture by black hole taking into account the loss-cone effect and stellar collisions by numerically evolving a Fokker-Planck equation in phase space.

(A. Mangalam)

Explaining the observed polarization from brown dwarfs by single dust scattering : Recent observation of linear optical polarization from brown dwarfs confirms the dust hypothesis in the atmospheres of brown dwarfs with effective temperature higher than 1400 K. The observed polarization could arise due to dust scattering in the rotation induced oblate photosphere or due to the scattering by non-spherical grains in the spherical atmosphere or by the anisotropic distribution of dust clouds. Assuming single scattering by spherical grains in a slightly oblate photosphere consistent with the projected rotational velocity, the observed optical linear polarization is modelled by taking grains of different sizes located at different pressure height and of different number density. Minimum possible oblateness of the object due to rotation is considered in order to constrain the grain size. It is shown that the observed polarization from the L-dwarfs 2MASSW J0036+1821 and DENIS-P J0255-4700 can well be explained by several sets

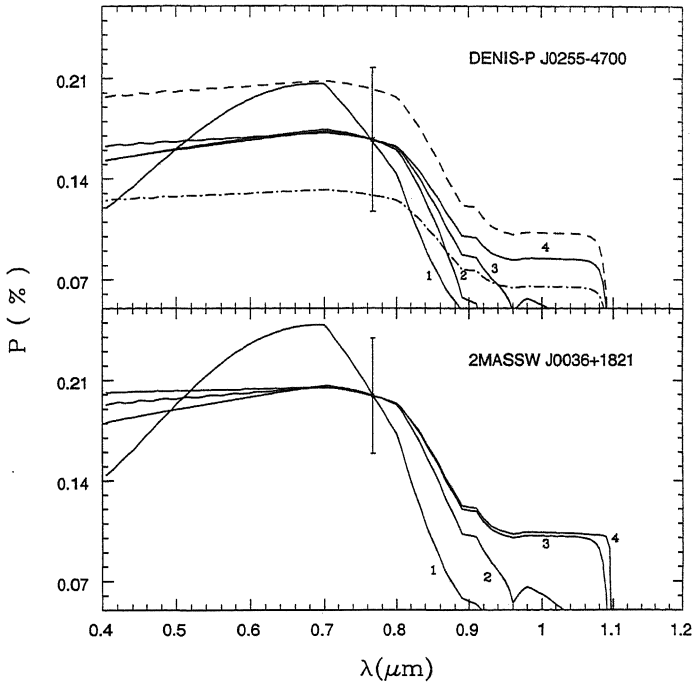


Figure 19 : Degree of polarization as a function of wavelength for the two L dwarfs. the numbers associated with each curve represent different sets of dust parameters. The observed polarization is at 0.768 micron.

of dust parameters and with the minimum possible oblateness (Figure 19). Models for the observed polarization constrain the maximum size of grains. It is emphasized that future observations of polarization at the blue region will further constrain the grain size.

(Sujan Sengupta)

Close binary stars : Expert systems: We are working on expert systems to handle the multiple kinds of data.The European Space Agency is planning a large mission called GAIA that will make enormous number of observations - astrometric, photometric, spectroscopic - of Galactic stars. Among these observations will be many light curves of eclipsing binaries. There also will be spectroscopy and other kinds of observations of eclipsing binaries. The very large number of observations will require automated processing, and the logical way to do the processing is via the discipline of Expert Systems.

We are dealing with geometrical aspects of the eclipsing binary systems and we will be interacting with Expert Systems programs (deciding on best software to use and implementing specific rules for analyzing eclipsing brraries) and also writing programs to interface with Expert Systems programs. We are trying to install some of the available softwares like Prolog, Focl, Babylon, Mobal, Mike Clips etc and checking the suitable software for above said problem. This work is in progress.

(Srinivasa Rao and R.Wilson*)

Classification of extra-solar planets and the effects of large condensates on the reflection spectra of irradiated extra-solar planets : Using luminosities of the primary stars and the orbital distances of the planets, we construct four regions in the luminosity-orbital distance parameter space and assign all known extra-solar planets to these regions (Figure 20). The surface temperature of a planet due to the radiation incident on it from the primary star can then be determined from its class. We assume complete insolation of the planets and neglect the internal energy of the planets if any. Reflection of radiation by the upper atmosphere of a planet would make its effective temperature less than the temperature associated with the radiation received from the star. We find that among all the planets discovered so far, the number of Jupiter like planets having ammonia in their atmospheres is the least while the number of planets with water cloud and those without condensates are almost the same. We calculate the flux of the planet Upsilon Andr.d as observed from the earth by

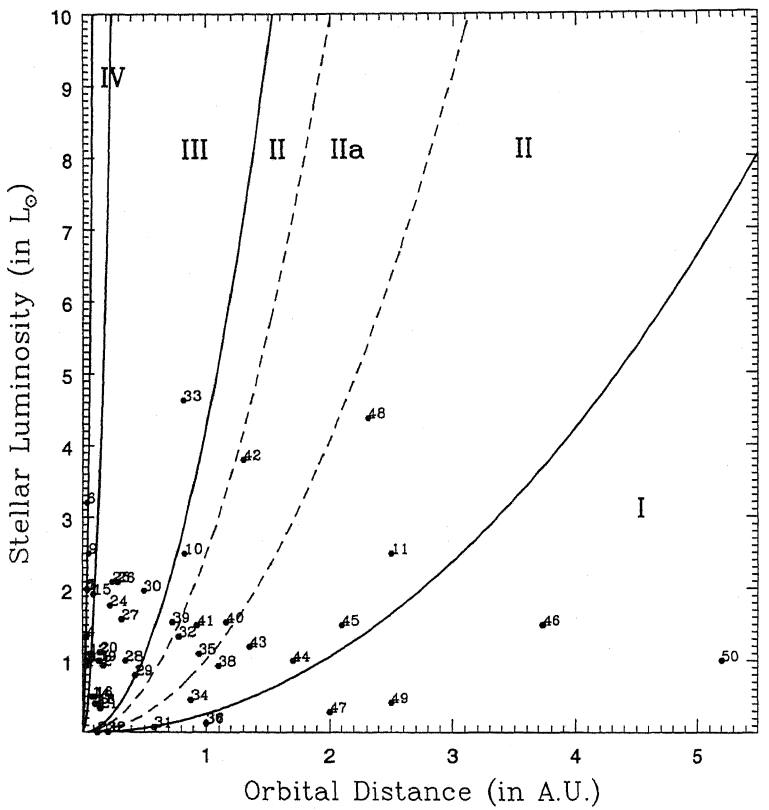


Figure 20. Classification of the discovered planets according to their surface temperature determined by the stellar luminosity and orbital distance. The numbers correspond to the planets as given in Table 1. The surface temperature for classes I, II, III & IV ranges between 200–120K, 400–200K, 1000–400K and 1600–1000K respectively. Region bounded by the broken lines (IIa) represents exo-planets with surface temperature similar to that of the earth. Class I represents planets with Jupiter type atmosphere.

Table 1. Physical parameters of the planets.

No.	Planet	d (in pc)	L_s (in $L_\odot$)	$M_p \sin i$ (in M_J)	R_{ps} (in A.U.)	T_p (K)
1.	HD83443b	43.54	0.93	0.35	0.038	1403.8
2.	HD83443c	43.54	0.93	0.16	0.174	656.0
3.	HD45375b	33.4	1.0	0.249	0.041	1376.2
4.	HD187123b	49.92	1.35	0.52	0.042	1474.4
5.	HD209458b	47.0	2.0	0.69	0.045	1562.1
6.	τ Boo b	15.6	3.2	3.87	0.0462	1737.7
7.	HD75289b	29.0	1.99	0.46	0.048	1510.63
8.	51 Peg b	15.36	1.0	0.47	0.05	1246.18
9.	Ups Andr. b	13.47	2.5	0.71	0.059	1442.53
10.	Ups Andr. c	13.47	2.5	2.11	0.83	384.6
11.	Ups Andr. d	13.47	2.5	4.61	2.5	221.6
12.	HD168746b	43.12	1.1	0.24	0.066	1110.8
13.	HD217107b	19.72	1.0	1.282	0.07	1053.2
14.	HD130322b	30.0	0.5	1.08	0.088	828.44
15.	HD108147b	38.57	1.93	0.34	0.098	1049.16
16.	55 Cnc b	12.53	0.5	0.84	0.11	706.5
17.	Gl 86 b	10.91	0.4	4.0	0.11	668.17
18.	HD38529	42.0	0.4	0.81	0.1293	616.3
19.	HD195019b	37.36	1.0	3.43	0.14	744.736
20.	HD6436b	40.32	1.12	0.48	0.15	740.16
21.	HD192263b	19.9	0.34	0.76	0.15	549.4
22.	Gl 876 b	4.7	1.01	1.98	0.21	197.0
23.	Gl 876 c	4.7	0.01	0.56	0.13	244.4
24.	ρ CrB b	17.43	1.77	1.1	0.23	670.2
25.	HR7875 b	25	2.1	0.69	0.25	670.89
26.	HD168443b	37.88	2.1	7.2	0.29	622.9
27.	HD121504b	44.37	1.58	0.89	0.32	522.27
28.	HD16141b	35.9	1.0	0.215	0.35	471.0
29.	70 Vir b	18.11	0.8	6.6	0.43	392.85
30.	HD52265b	28	1.98	1.05	0.5	477.1
31.	HD37124b	33.0	0.08	1.04	0.585	195.76
32.	HD134987b	25.0	1.34	1.58	0.78	333.12
33.	HD169830b	36.32	4.63	2.94	0.82	451.4

Table 1 continued.

No.	Planet	d (in pc)	L_s (in $L_\odot$)	$M_p \sin i$ (in M_J)	R_{ps} (in A.U.)	T_p (K)
34.	HD89744b	40.0	0.46	7.2	0.88	244.63
35.	HD92788b	32.32	1.1	3.8	0.94	294.34
36.	HD177830b	59.0	0.14	1.28	1.0	170.45
37.	HR5568b	6.0	0.13	0.75	1.0	167.3
38.	HD210277b	21.29	0.93	1.24	1.097	255.17
39.	HD82943b	27.46	1.54	0.88	0.73	363.3
40.	HD82943c	27.46	1.54	1.63	1.16	288.2
41.	HR810b	15.5	1.5	2.24	0.925	281.5
42.	HD19994b	22.38	3.8	2.0	1.3	341.2
43.	HD222582b	42.0	1.2	5.4	1.35	251.0
44.	6 Cyg B b	21.62	1.0	1.5	1.7	213.7
45.	47 Uma b	14.08	1.5	2.54	2.09	212.8
46.	47 Uma c	14.08	1.5	0.76	3.73	159.7
47.	HD10697b	30.0	0.29	6.59	2.0	144.6
48.	HD190228b	62.11	4.38	4.99	2.31	265.2
49.	14 Her b	18.15	0.42	3.3	2.5	133.1
50.	Jupiter	0.0	1.0	1.0	5.2	122

incorporating water condensates of different sizes and investigate the effects of the condensate size on the reflected flux. We find that as the size of the condensates increases from 0.1 μm to 1.0 μm, the amount of reflected flux increases by several orders of magnitude. However, the reflected flux doesn't change significantly if the size of the condensates is increased beyond a critical value.

(Sujan Sengupta, Ajit Kembhavi* and Vinod Krishan)

Observation of polarization from Brown dwarfs : In order to detect polarization and to study polarized radiation from brown dwarfs, a collaborative project with IUCAA, Pune has been ongoing. For this purpose IUCAA's image polarimeter IMPOL has been installed at VBT. IMPOL will be used in future to study polarization from Be stars, AGB stars, circumstellar disc etc.

(Sujan Sengupta)

Microflares in accretion disks : We have investigated the phenomenon of explosive chromospheric evaporation from an accretion disk as a mechanism for fast variability in accreting sources such as low mass X-ray binaries and active galactic nuclei. This has been done in the context of advection dominated accretion flows, allowing both high and low states to be considered. This mechanism can in principle produce sub-millisecond timescales in binaries and sub - minute timescales in active galaxies. However, even considering the possibility that large numbers of these microflares may be present simultaneously, the power emitted from these microflares probably amounts to only a small fraction of the total X-ray luminosity.

(V. Krishan, S. Ramadurai* and P.J. Witta*)

Coherent plasma processes in Active Galactic Nuclei : The physics of active galactic nuclei (AGN) and related objects is one of the most actively pursued areas of astrophysics. Their large luminosities over the entire electromagnetic spectrum combined with extremely short time variability has stimulated a large number of astrophysicists to propose rather unconventional ideas. A variety of radiation mechanisms such as, thermal, synchroton and Compton processes have been proposed to account for the complex continuum emission. It is only recently that the role of plasma radiation mechanisms has been shown to be of the utmost importance. It is demonstrated how a combination of the stimulated Raman and Compton scattering processes accounts for the major part of the spectrum, taking 3C273 as an example. In addition plasma mechanisms for the heating of the emission line region, absorption of 21 cm radiation, producing time variability on different time scales and pair production and annihilation are also discussed.

(V. Krishan)

Frequency drift rate measurements of coronal temperatures : The frequency drift rates of radio emission are traditionally used to determine the velocity of the exciting agency for a chosen

coronal density model. The speed of the exciting agency, say an electron beam, is assumed to remain constant during its propagation through the radio emission region. Here, we allow the electron beam to decelerate either due to its collisions with the ambient coronal particles or due to any of the diffusion and plasma transport mechanisms. The deceleration is related to the time derivative of the frequency drift rate. Thus, assuming the plasma mechanism for the radio emission combined with the slowing down of the electron beam enables us to self consistently determine the plasma density profile and the temperature of the radio emitting region. Conversely, the frequency dependence of the drift rate can be determined for a given temperature of the emission region. A comparison with the observed drift rate can then tell us about the validity of the beam slow - down model.

(V. Krishan, F.C.R. Fernandes* and H.S. Sawant*)

Astrobiology : We have explored at length the following : (1) General conditions for the existence of life including habitable zone around stars , space habitats etc. (2) Introduction to the theories of the origin of life including prebiotic soup theory, panspermia, dinosaur extinction, modern ideas etc.(3)Anthropic principle (4) communication with extra -terrestrial civilisations (radio, lasers, biogenetics carriers etc.) (5) Interstellar flight (6) Biomolecules and biogeochemical cycles (7) Scaling laws in astrobiology (8) Space missions .

(C. Sivaram and A. Shastri*)

Black hole thermodynamics and varying constants : Recent observations especially of distant supernovae and anisotropies in the CMBR seen to provide strong evidence of a dark energy (or quintessence) dominating the dynamics of the universe with indications that this repulsive component might even be varying with time (quintessence). Observational evidence of shifted spectral lines in distant quasars suggests that the fine structure constant is slowly increasing over cosmological time scales . This may provide support to some recent theories suggesting a varying electric charge or varying light speed. A critical study is made as to how black hole thermodynamics can constrain variation of several constants including a varying cosmological constant. The conclusion is that such variations cannot be ruled out by black hole physics.

(C. Sivaram)

Black hole and quintessence : The growing consensus at present (in the past three years) is a picture of a universe dominated by a time varying cosmological constant (quintessence). The present author was the first to propose such a picture in the context of one of the earliest vacuum dominated early universe models as far back as 1975 (Found. Phys.Lett. 6, 717 (1976); Phys.lett.60B,161(1976) where a vacuum term varying with epoch as t^{-2} was proposed. This is just what is suggested by several authors in recent years.

Such background terms would introduce corrections to Schwarzschild or charged black hole solutions. Constraints from such solutions to the behaviour of the vacuum term with time was studied. It was shown that growing quintessence was untenable and $n < 3$.

(C. Sivaram)

Neutrino vs Gamma ray bursts : The high energy density conditions in the sources for gamma ray bursts should also produce high energy neutrinos. In many cases, the neutrinos would escape with high energy, but the gamma rays would because of the high density of the medium be scattered to lower energies. So, there could be sources emitting high energy neutrinos but hardly any gamma ray.

These kinds of sources could be more numerous and may be detectable in high energy neutrino detectors.

(C.Sivaram)

Dynamics of self gravitating systems like galaxies and star clusters : It has long been felt that in spite of several developments in computational schemes there is a need for sound analytical treatment of self gravitating systems. The method should take care of (a) selfconsistent gravitational field and (b) damping due to dynamical friction. The Chandrasekhar dynamical friction formula has been shown to be amenable to simple approximations (KS test gives 99% fit) and hence the dynamics can be easily handled. This method was used in understanding the origin of corona in open clusters and the results are extremely promising.

(S. Chatterji, Brijesh Kumar*, R. Sagar*)

Detectability of TeV gamma rays of proton synchrotron origin from Gamma ray bursts : Gamma Ray Bursts (GRBs) have been proposed as one *possible* class of sources of the Ultrahigh Energy Cosmic Ray (UHECR) events observed up to energies $\gtrsim 10^{20}$ev. The synchrotron radiation of the highest energy protons accelerated within the GRB source should produce gamma rays up to TeV energies. We have calculated the expected flux of prompt GeV–TeV photons from GRBs due to this process and studied the detectability of these photons in the up-coming ICECUBE muon detector in the south pole which can detect TeV energy photons by detecting the muons produced by TeV photons in the Earth's atmosphere. We have made detailed calculations of the internal optical depth of GeV—TeV photons against pair production due to their interaction with the lower energy gamma ray photons within the GRB source. The emerging GeV–TeV gamma ray flux is subject to internal attenuation due to this process as well as further attenuation during propagation from the source (which are at cosmological distances) to Earth due to pair production on the intergalactic infrared background photons, both of which we include in our calculation of the emergent flux of GeV–TeV gamma rays from GRBs. We find that while the TeV photon flux at Earth from GRBs is generally small, it depends significantly on the Lorentz factor of bulk flow of matter in the underlying fireball model as well as on the spectral index of the accelerated protons' energy spectrum. Our conclusion is that some of the closeby GRBs (with redshift $\lesssim 0.1$, say) with sufficiently large Lorentz factor of $\gtrsim 400$ and sufficiently hard proton spectral index ($\lesssim 2$) may be detectable at TeV energies (within the context of the proton synchrotron model studied here) in a detector like the up-coming ICECUBE detector with a signal-to-noise ratio >5 or so. Detection of such photons in the TeV energy range with the spectrum predicted in our calculation will provide important clues as to the nature of GRBs and provide strong support to the GRB origin of the UHECR.

(P. Bhattacharjee and N. Gupta*)

The fragmentation function of quarks and gluons to hadrons at ultra high energies : In the so-called "Top–Down" scenario of origin of Ultra High Energy Cosmic Rays (UHECR), the predicted spectrum of UHECR is determined by fragmentation of quarks and gluons into hadrons. These "Fragmentation Functions" (FFs) are not calculable in general within perturbative QCD. However, their *evolution* with energy can be calculated within perturbative QCD to any order. On the other hand, there is a semi-analytical method of directly calculating the FFs in perturbative QCD under the so-called "Modified Leading Logarithm Approximation" (MLLA), *provided* one makes an extra *hypothesis* called "Local Parton Hadron Duality" (LPHD) which is physically well-motivated but remains unproven. The FFs experimentally measured at "low" energies (~ few hundred GeV) in e^+e^- colliders agree well with the predictions of MLLA-LPHD formalism. In this work, we compare the FFs at UHECR energy regions predicted within the MLLA-LPHD formalism with those obtained by evolving the FFs measured at laboratory energies to UHECR energy region through perturbative QCD to leading order. We find that the MLLA-LPHD provides a good description of the FFs even at UHECR energy region, and as such, the baseline injection spectrum of UHECR in the top-down scenario can, to a good approximation, be taken to be that given by the MLLA-LPHD. This is

advantageous because the resulting simple analytical form of the spectrum allows analytical calculations of the final flux of the UHECR at Earth.

(P. Bhattacharjee and R. Basu*)

Galaxy interactions : Galaxy interactions involving systems of different types generally produces interesting morphological features in the components. The interaction between a disk and a sphere pair of galaxies has been explored in a limited number of works. The qualitative difference in the tidal effects due to the addition of one or more components to the disk galaxy are examined in the light of numerical simulations. The computations have been performed using the GRAPE special purpose computer. The model consists of a disk galaxy with three components - a bulge, a disk and a halo - and a Plummer model spherical galaxy undergoing head-on collision with a relative velocity of 1000 kms^{-1}. Several simulations have been performed with the orbital plane inclined to the disk plane by various angles. None of the simulations leads to the merger of the galaxies by tidal capture irrespective of the inclination of the orbital plane to the disk plane. The collision produced a mass loss of less than 50 per cent and consequently both the galaxies do not get tidally disrupted but manage to survive the encounter. The mass ratio of the galaxies is seen to be more important in producing tidal damage to the less massive galaxy rather than the inclination of the orbital plane to the disk plane. The generation of spiral features is more pronounced in collisions where the disk is less massive than the spherical galaxy. It is remarkable that when the disk galaxy is normal to the orbital plane, a ring structure is formed in the disk galaxy just after the instant of closest approach and it almost disintegrates within about five disk crossing times. Further work is in progress.

(P.M.S. Namboodiri)

6. Physics and mathematics

Non-linear optics

Light-induced absorption in photorefractive $BaTiO_3$ crystals : Photorefractive crystals show light-induced absorption and refractive index changes that can be exploited in numerous applications in optics and related fields. We have carried out a detailed experimental investigation of light-induced absorption in rhodium doped and un-doped $BaTiO^3$ crystals at different wavelengths and intensities. In our earlier studies, the absolute measurements of absorption were made with single beam by measuring the reflection and transmission of the beam through the crystals. Multiple reflections from front and back face of the crystal and angular dependence of reflectivity severely affect the accuracy of the measurements. Therefore, a two-beam measurement technique was adopted. A relative change in absorption coefficients $\Delta\alpha$ can be measured for a weak probe beam by uniformly illuminating the crystal with an expanded pump beam at different wavelength. Selecting the pump and probe beams at different wavelengths helps eliminating the beam coupling effects which otherwise could be mistaken for absorption. The measurements of light-induced absorption changes (at 488 nm and 514 nm pump) were carried out for probe beams at 633 nm, 543 nm, 750 nm and 800 nm. We also observed anomalous absorption variations in Rh doped $BaTiO^3$ at 633 nm probe and 514 nm pump that has not reported in earlier studies. This anomalous temporal evolution of absorption is shown in the Figure 21.

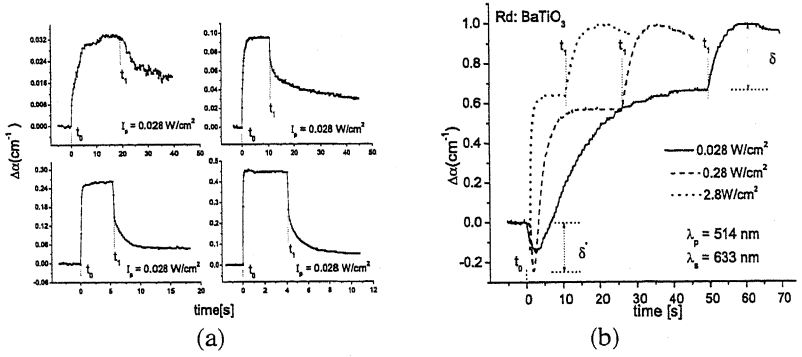


Figure 21. (a) Light-induced absorption curves (b) Anomalous absorption change observed.

The exact mechanism of this behavior has not been clearly understood, but based on some earlier studies we attribute this to thermal effects and also to the possibility of additional photorefractive centers becoming active. The rate equations were solved numerically to derive an analytical expression for steady-state absorption change. Steady state absorption change as a function of pump beam intensity is shown in Figure 22.

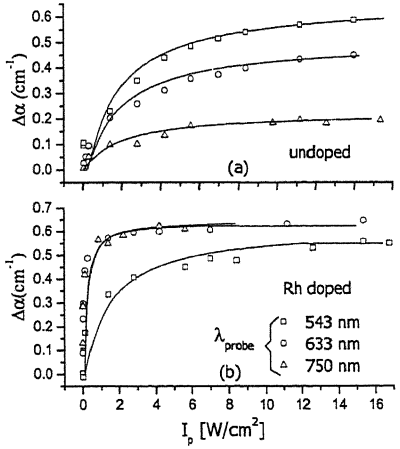
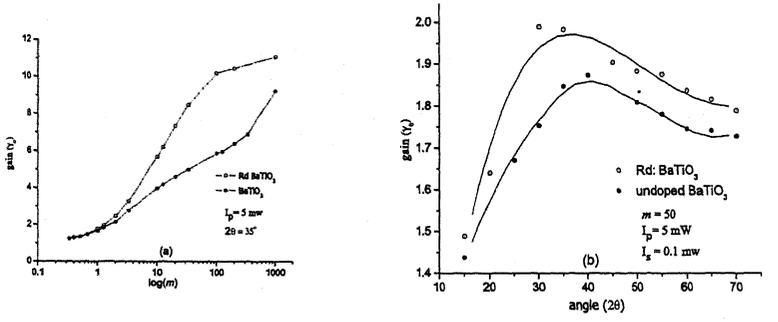


Figure 22. Steady-state light-induced absorption change. Experimental data is represented by symbols, solids curves are based on theoretical calculations.

Experiments also include the determination of two-wave mixing gain and its angular dependence (shown in Figure 23). Small signal gain coefficient was measured using standard two-wave mixing set-up at different intensity ratios and beam crossing angles.



(a) (b)

Figure 23. Two-wave mixing gain (a) as a function of intensity ratio (b) beam crossing angle

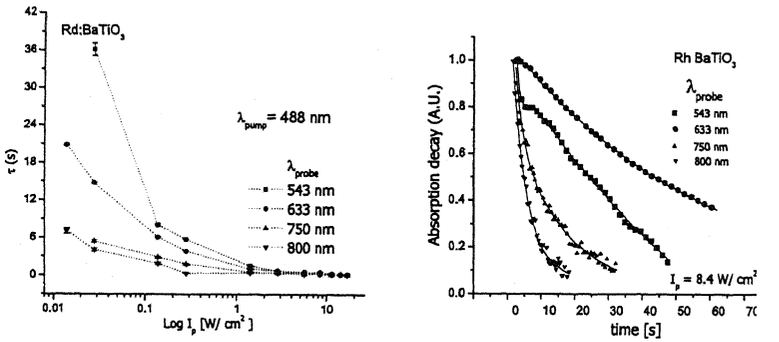


Figure 24. (a) Absorption rise-time constant (b) dark decay process of light-induced absorption.

Various model parameters like absorption build-up, decay time scales (shown in Figure 24), thermal excitation rates carried out at different laser intensities.

We note that the dark decay at the 543nm probe and 488nm pump occurs in two separate steps. It shows an initial fast relaxation having two time constants (τ_3~ 50ms and τ_2 ~ 0.7s) followed by a slow relaxation with a longer time constant (~ 60s). The other combinations show monoexponential decays of different time scales. All these results emphasize that the light-induced absorption can greatly influence the dynamics of holographic recording in photorefractive crystals.

(Ravinder Kumar Banyal and B. Raghavendra Prasad)

Nuclear fusion reactions at astrophysically relevant energies : It is well known that nuclear fusion reactions are the primary sources for the vast amounts of energy radiated by the Sun and the stars and it is interesting to examine the current state of knowledge of these processes. The earliest estimates of the reaction rates by Fowler, Caughlam and Zimmerman [Ann. Rev. Astron. Astrophys. **5** (1967) 525] have been revised in the 90's by Hale et al [ENDF/B-VI, evaluation, material 125, revision 1 (1991)] and Smith et al [Astrophys. J. Suppl. Ser. **85** (1993) 219]. If we consider the simplest example of $n + p \rightarrow d + \gamma$, which is part of the *pp* chain, converting hydrogen into helium and is responsible for the production of deuterium in the early universe, the estimates of Hale et al and Smith et al agree with each other within 5% variation but differ considerably from that of Fowler et al. Since the deuteron with its low binding energy is rapidly destroyed in stellar interiors, Smith et al have pointed out that *the ratio of the primordial abundance of deuterium to that observed today could be anywhere from 1 and 50* due to the uncertainties in the reaction rates. This in turn contributes to the uncertainties in the determination of the relative abundances of the heavier elements in the early universe.

It is heartening to note that laboratory studies of the cross section for $n + p \rightarrow d + \gamma$ in the astrophysically relevant range $10\text{keV} \leq E_n \leq 600$ keV of neutron

energies E_n have been recently reported [T. S. Suzuki et al., AstroPhys. J. **439** (1995) L59; Y. Nagai et al., Phys. Rev. C **56** (1997) 3173] and an experimental study of the fusion reaction has also been reported by Müller et al [Proc. Int. Workshop on Particle Physics with Slow Neutrons, ILL, Grenoble, France, 22-24 Oct 1998; Nucl. Instr. Meth. **A440** (2000) 736] employing a beam of polarized neutrons on a polarized proton target. In this context we [G. Ramachandran and P. N. Deepak] have developed a model-independent approach to discuss this reaction. We find that the differential cross section derives contributions from the initial spin-singlet and the triplet states as well as a cross term arising out of singlet-triplet correlation when the two nucleons are polarized in the initial state. Since the dominant contribution to the reaction at thermal neutron energies is from the $^1S_0$ state, leading to an isovector $M1$ transition, the study of the interference term assumes importance to examine the role of the isoscalar $M1$ and $E2$ amplitudes due to capture from the initial $^3S_1$ state, especially since model-based theoretical calculations by Sato et al [Proc. Int. Symp. on Weak and Electromagnetic Interactions in Nuclei, eds. H. Ejiri, T. Kashimoto and T. Sato [World Scientific, Singapore, (1995) p 488] indicate that the dominant isovector $M1$ amplitude decreases with energy, while the isovector $E1$ transition from $^3P_1$ increases with energy and that the two strengths equal at around 500 keV within the domain of the energies of astrophysical interest.

A highlight of our study is that the contribution of the singlet-triplet interference term can be detected experimentally by looking at the photon polarization in suitably designed polarized beam and polarized target experiments, where the neutron and proton polarizations are opposite to each other or orthogonal to each other.

(G. Ramachandran, P. N. Deepak and S. Prasanna Kumar*)

Meson production in *NN* collisions : There has been a spurt of experimental activity in studying pion and heavy meson production in NN collisions recently at IUCF, CELSIUS, SATURNE, COSY, TRIUMF. The motivation is to study the spin-dependence of the nuclear force at very short distances, since large momentum transfers are involved even at close to threshold energies. The reaction amplitude is entirely spin-dependent, if we consider, for example, the particular case of neutral pion production in *pp* collisions. Our earlier work [G. Ramachandran, P. N. Deepak and M. S. Vidya, Phys. Rev. C **62** (2000) 011001(R); G. Ramachandran and P. N. Deepak, Phys. Rev. C **63** (2001) 051001(R); P. N. Deepak and G. Ramachandran, Phys. Rev. C **65** (2002) 027601] on pion production is being extended now to study heavy meson production using our model-independent irreducible tensor approach.

(G. Ramachandran, P. N. Deepak and M. S. Vidya*)

Spin-squeezing and correlations : The concept of spin is a fascinating topic in quantum theory. Defined through the commutation relations $\boldsymbol{J} \times \boldsymbol{J} = \mathrm{i}\,\boldsymbol{J}$ in natural units, the three components J_x, J_y, J_z satisfy the uncertainty relations $\Delta J_x^2 \Delta J_y^2 \geq \langle J_z \rangle^2$, x,y,z cyclic, which bears a comparison to the Heisenberg uncertainty relation $\Delta x^2 \Delta p_x^2 \geq 1/4$ for position x and the canonical momentum p_x and hence allows us to define squeezed states. Considering two mutually exclusive classes viz., oriented [R. J. Blin-Stoyle and M. A. Grace, Hand Buch Der Physik, **42** (1957) p 557] and non-oriented states [G. Ramachandran and M. V. N. Murthy, Nucl. Phys. **A323** (1979) 403; **A337** (1980) 301; G. Ramachandran and V. Ravishankar, J. Phys. G **12** (1986) L143], we have shown that the oriented states are not squeezed, while non-oriented states exhibit squeezing. Using a new scheme developed earlier [K. S. Mallesh, Swarnamala Sirsi, Mahmoud A. A. Sbaih, P. N. Deepak and G. Ramachandran, J. Phys. A: Math. Gen. **33** (2000) 779; **34** (2001) 3293] for construction of non-oriented spin j states using $2j$

spinors oriented along different axes and specialising for $j = 1$, leads to demonstrate that squeezing arises from intrinsic quantum correlations. This study has now been extended to coupled spin states which do not possess a sharp spin value. A general squeezing criterion has been obtained such that a direct product state for two spinors is not squeezed. The squeezing aspect of entangled states is also studied in relation to their spin-spin correlations.

(K. S. Mallesh*, A. R. Usha Devi*, Swarnamala Sirsi*, Mahmoud A. A. Sbaih*, K. B. Nalini*, P. N. Deepak and G. Ramachandran)

Polarization of line radiation in the presence of external electric and magnetic fields : The Zeeman splittings of an atomic energy level with spin J into $2J + 1$ levels and the consequent polarization of line radiation in uniform magnetic fields is a very useful diagnostic tool to detect and measure the magnetic fields in the solar and stellar environments. In recent years, new and highly sensitive imaging polarimeters have given access to a wealth of previously unknown spectral structures [see J. O. Stenflo & K. N. Nagendra Proc. of Solar Polarization Workshop 1 (SPW I) 1996, K. N. Nagendra & J. O. Stenflo Proc. of SPW II 1999, G. Mathys et. al. ASP Conf. Ser. **248** 2002, J. Trujillo Bueno et. al. Eds Astrophysical Spectropolarimetry, Cambridge 2002], the interpretation of which have already revealed some interesting physical effects. In particular the use of line polarization as a diagnostic of ambient electric fields in solar atmospheres was considered by S. A. Kazantsav & J. C. Henox, Polarization Spectroscopy of Ionized Gases, Kluwer, 1995.

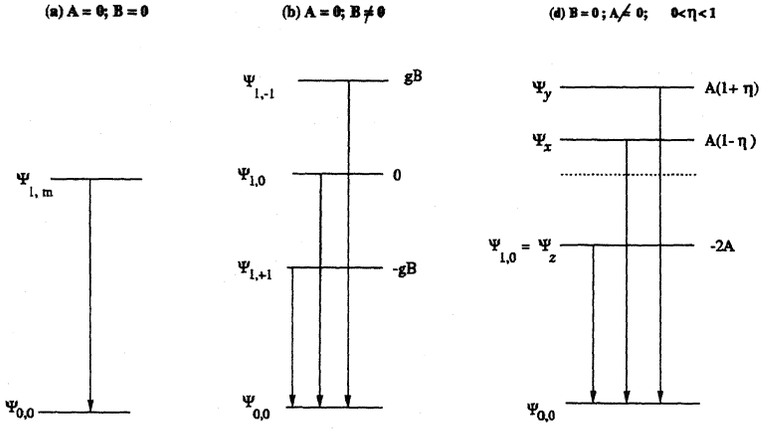


Figure 25. Comparison of level splitting for a $J = 1$ state in pure magnetic and pure electric quadrupole fields.

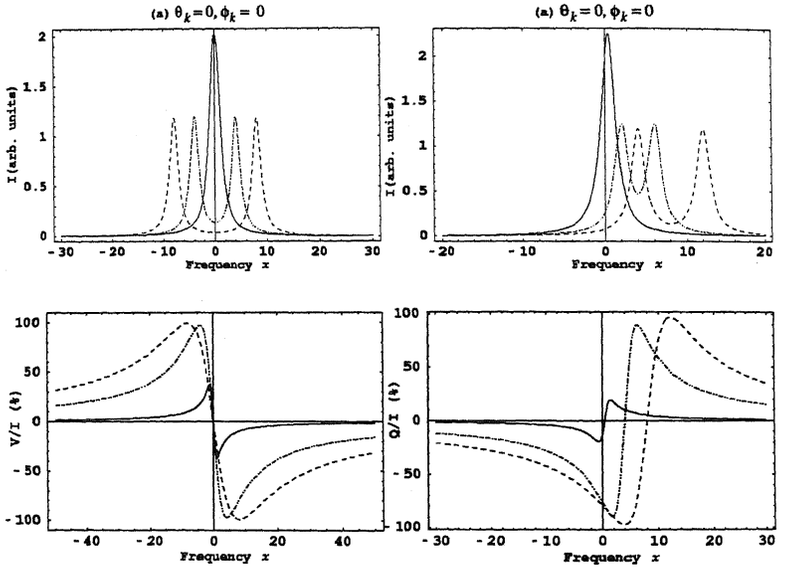


Figure 26. The Stokes I and V parameters of pure magnetic field case and the Stokes I and Q parameters of pure electric quadrupole field are plotted for the line of sight which is along the Z axis of the principal axis frame.

In this context a collaborative programme of research was initiated by K. N. Nagendra, G. Ramachandran, R. Vijayashankar with Yee Yee Oo and Sharath Ananthamurthy of Bangalore University and Swarnamala Sirsi of University of Mysore (who joined the collaboration at a later stage) on a systematic theoretical study of the effects of electric fields (in addition to those produced

by magnetic fields) on the polarization features of line radiation. To start with we considered a simple example of an atomic transition from a spin 1 level to a spin 0 level when an external electric field with nonzero electric quadrupole terms. In contrast to the Zeeman splitting with equal spacing (Figure 25) produced by an uniform external magnetic field of strength B, a pure electric quadrupole field produces a characteristic splitting with unequal spacing as shown in Figure 25c, where A denote the strength and η the asymmetry parameter characterizing the quadrupole field. Here (θ_k, ϕ_k) denote the polar angles of line of sight with respect to the Principal Axis Frame of the electric quadrupole field.

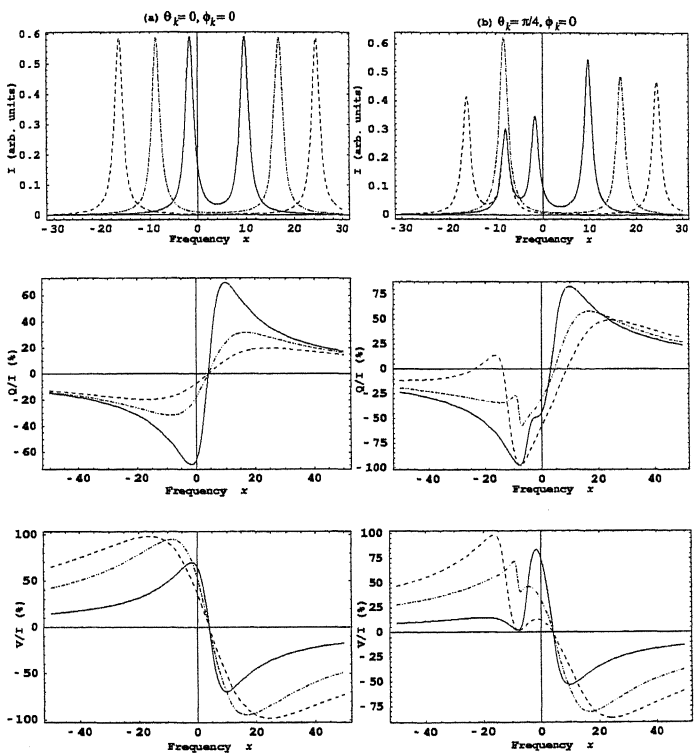


Figure 27. The effect of combined magnetic and electric quadrupole fields on Stokes line profiles for $\eta = 1$.

While the line components emitted along the quantization axis are circularly polarized in Zeeman effect, they are, in contrast, linearly polarized in the case of a pure quadrupole electric field as shown in the Figure 26. When both the electric & magnetic fields are present, both Q and V manifest themselves as shown in Figure 27 along with I. Lack of azimuthal symmetry in the quadrupole electric field (when $\eta \neq 0$) leads to polarized line components which appear quite differently for different azimuthal angles of the line of sight.

Further investigations are in progress.

(Yee Yee Oo*, K. N. Nagendra, Sharath Ananthamurthy*, Swarnamala Sirsi*, R. Vijayashankar and G. Ramachandran)

Atomic Physics : I am developing Fock-space based relativistic coupled cluster and many-body perturbative scheme to study atomic and molecular systems containing heavy elements. I have studied the ground and excited states of transition metal nitrides and alkali metal halides using coupled cluster and many-body perturbation theory.

Also, I have undertaken (in collaboration with Prof. Das) a DAE (Department of Atomic Energy) project on Atomic Parity violation. This project mostly focused on the advanced computational approaches to many-electron systems. I am a co-investigator of Indo-Hungarian project which also focused on advanced computational approaches and theories to many-electron systems.

(Rajat Kumar Chaudhuri)

Optics of periodic and random media: A new method has been developed to study the propagation of a wave in a random medium, being applicable in bulk media and from scattering from periodic and random surfaces. Noting that the scattered intensity is of the Raman Nath we have developed, for the first time, a Matched Filter method which can be employed to recover the hidden randomness even though conventional methods would never allow such detections to succeed. This method can be incorporated

with another method, i.e. recording the scattered intensity by sweeping the frequency of the incident radiation, which directly gives the amplitude of the grating. This method shows great promise in enhancing the performance of gratings, including those of highly sensitive echelle type gratings.

(S.Chatterjee, B. Raghavendra Prasad and Ravinder Kumar Banyal)

Non-Accelertaor Particle Physics : Important results have been obtained for parity nonconservation(PNC) in atomic caesium.Using a relativistic coupled-cluster approach, we have for the first time evaluated the contributions of a complex class of many-body effects arising from the non-linear clusters to the parity nonconserving electric dipole transition amplitude.This is a crucial ingredient in probing the Standard Model of particle physics. We have made considerable progress in our coupled-cluster formulation of the electric dipole moment of atomic mercury and expect to have results shortly.This work will have important implications in our understanding of a certain class of hadronic CP violation. We have also contributed significantly to advance our present understanding of the relativitic many-body theory of hyperfine interactions in atoms.

(B.K. Sahoo, K.V.P. Latha, C. Sur, R.K. Chaudhuri, B.P. Das, D. Mukherjee and H. Merlitz)

Atomic Astrophysics : Studies of forbidden atomic transitions are of importance in astrophysics. We have used the relativistic coupled-cluster theory to demonstrate that it is possible to calculate magnetic dipole and electric quadrupole transition amplitudes for heavy atomic systems to a high degree of precision.

(B.K. Sahoo, S. Majumder, R.K. Chaudhuri, B.P. Das, D. Mukherjee and H. Merlitz)

7. Indian Astronomical Observatory

The primary activity during the year was centred around releasing the 2-m Himalayan Chandra Telescope to astronomers with all the first generation instruments. Significant time was also spent on further finetuning of the telescope and on experience in its maintenance. Site characterisation studies also continued at the site in Hanle and were initiated at a new site at Polakongka La.

The following team has participated in all the activities : T.P. Prabhu, G.C. Anupama, B.C. Bhatt, D.K. Sahu, P.S. Parihar, M.P. Singh, D. Angchuk, T. Dorjai, T. Tsering. Additional contributors are listed under specific heads.

The 2-m Himalayan Chandra Telescope

The telescope was well-balanced with all the first generation instruments in place. Efforts were made to minimise the cable torque at the Cassegrain focus of the telescope. This has helped in improving the pointing and open-loop tracking performance of the telescope. Telescope pointing of 3-4 arcsec rms is sustained. The median open-loop tracking accuracy of 0.14 arcsec/minute is achieved. A value of 0.05 arcsec/min is achieved over a good fraction of the sky. The mirror support system was finetuned in August 2002 to achieve an image quality of 0.7 arcsec diameter (80% power).

The announcement of opportunity for Cycle 1 observations (May - August 2003) was made in February 2003. The HFOSC instrument was initially offerred while the efforts continued on making the other two instruments operational.

1. The Himalayan Faint Object Spectrograph-Camera (HFOSC) : The HFOSC was commissioned on the 2-m HCT through two trips to the site in July and October 2002. The instrument has since been in use for observations required for verifying the limiting performance of the instrument, for characterisation of atmospheric extinction, and some science observations such as the GRB 021004 and 021211 afterglows.

2. The Near-Infrared Camera : The software for the control of the camera and for data acquisition is developed at IIA. It was tested at IR Laboratories, Tucson and Astrocam, San Diego, in November 2002. The final test with the cooled dewar was carried out in January 2003. The instrument was transported to the site and installed at the telescope in March 2003. Further commissioning of the tests were planned for execution from the remote control station at CREST during April, 2003)

(U.S. Kamath and T.P. Prabhu)

3. High-resolution CCD Imager : Further improvements to the CCD system developed in IIA around 2kX4k EEV CCD were undertaken in the laboratory. The instrument is planned to be commissioned on the telescope early in 2003-04.

(R. Srinivasan)

4. Autoguider : The efficiency of the autoguider of original design is found insufficient for efficient utilization of the telescope time. An advanced design autoguider is being planned to be fabricated in collaboration with the Copenhagen University Astronomical Observatory, Denmark. The system will use a fixed off-axis field of 8 arcmin x 12 arcmin with corrector and reducing optics, and a CCD detector. The design goals are to reach a magnitude limit of 17 at 1 Hz rate. The chance of not finding a guide star will be one in 170,000.

High-Altitude Gamma-Ray (HAGAR) Telescope :

TIFR, Mumbai, and the Institute have finalized their plans to establish an atmospheric Cerenkov telescope array at Hanle for observing the very-high energy gamma rays from celestial sources. The low atmospheric path length and high transmission at Hanle is expected to make it possible to detect gamma rays of even a few tens of GeV using ground-based techniques. Experiments were carried out by the TIFR group at Hanle to verify the theoretical simulations made in these estimates.

The hexagonal array of 50 m radius will consist of 7 telescopes. Each telescope is similar to the ones deployed in PACT at Pachmarhi, though mounted altitude over azimuth. Each telescope mount will hold 7 sub-telescopes of 0.9 m diameter each. There will thus be 49 detectors in the array. The total collecting area will be 31 square metres. The wavefront sampling techinque will be used to reject the cosmic ray background.

Two prototype telescopes are planned to be fabricated and tested in Bangalore during the year 2003-04.

(IIA - TIFR HAGAR Team)

Seeing Monitor

The Differential Image Motion Monitor was operated both with the Meade 30 cm telescope and with the 25 cm finder telescope attached to the HCT. Some improvements were done to the software so that guiding controls can be given to the Meade 30 cm telescope based on DIMM images. 25 cm finder data provides information on the HCT dome seeing as well. Based on the current experience, it is planned to automate the 30 cm Meade telescope for DIMM as well as extinction observations during the next year.

The 220-GHz radiometer

The 220-GHz radiometer continued to operate through its third year without any major problems. The data shows that on an average the site characteristics continued to be similar to the previous two years.

(P.G. Ananthasubramanian*, S. Yamamoto* and T.P. Prabhu)

Automated weather station

The automated weather station installed in 1996 was decommissioned for servicing after verification of the performance of the new weather station installed with the HCT. The data from the new weather station (ambient temperature and relative humidity, wind speed and direction, and pressure) are continuously logged at 5 s intervals by the weather server. The data is used for validation of telescope and dome operation during the night. It is also used to estimate the surface water vapour pressure and other parameters of interest for site characterisation.

Site Characterisation at Polakongka La

The groundbased observatories for infrared and submm observations require a high-altitude dry site. While Mt. Saraswati is currently world's highest observatory, still higher sites need to be identified and developed in the future. Such projects are being undertaken in the southern hemisphere at Atacama Desert, Chile, internationally. Ladakh provides an excellent opportunity in the northern hemisphere, and the presence of IAO at Hanle makes it easier for us to characterise new sites in the nearby regions.

IIA, in collaboration with the Harvard-Smithsonian Center for Astrophysics, U.S.A., initiated a program of site characterisation at Polakongka La (5000 m above msl), near Puga valley of Ladakh, in December 2002. A computer controlled digital camera has been installed for continuous monitoring of a part of sky and a part of ground to study the statistics of

cloudfree days and the amount of snowfall. More instruments are expected to be added in 2003-04.

(T.K. Sridharan* and IAO Team)

Infrastructure for solar power supply : 12.5 KVA inverter supplied for the spv.system by M/S TATA BP LTD., was not functioning.In house effort made by M/S TATA BP to set right was not adequate.Consultants from their parent company M/s. Sunpower power system, Germany,could identify that few PCB's were defective. The defective PCB's were sent to their unit in Germany, rectified and the unit was put into working condition.

As an effort to have 100 percent standby unit, "AES" make 12.5 KVA spv inverter to be fully compatible with 31.3 kwp Spv solar system at Hanle,Ladakh was supplied, tested and commissioned at the observatory campus.

Night sky extinction and brightness at Hanle : The night sky extinction and brightness at IAO, Hanle was estimated based on observations of standard photometric fields observed in the *UBVRI* bands using the 2-m HCT during 2000 December, 2002 October, 2002 November, 2002 December and 2003 January. The mean extinction and night sky brightness are as follows:

Band	Extinction mag	Sky brightness mag/arcsec^2
U	0.353 ± 0.037	23.64 ± 0.57
B	0.209 ± 0.029	22.94 ± 0.50
V	0.121 ± 0.032	21.52 ± 0.21
R	0.0823 ± 0.037	20.20 ± 0.35
I	0.0497 ± 0.027	18.60 ± 0.21

The extinction in the *U* band is found to be lower compared to Mauna Kea and the theoretically expected value for an altitude of 4500 m. The extinction in other bands are similar to that estimated for Mauna Kea.

(P.S. Parihar, D.K. Sahu, B.C. Bhatt, A. Subramaniam, G.C. Anupama and T.P. Prabhu)

Optical observations of INSAT satellites : A new observational program has been initiated jointly by the ISRO - Master Control Facility at Hassan and IIA to carry out astrometry of the INSAT satellites.

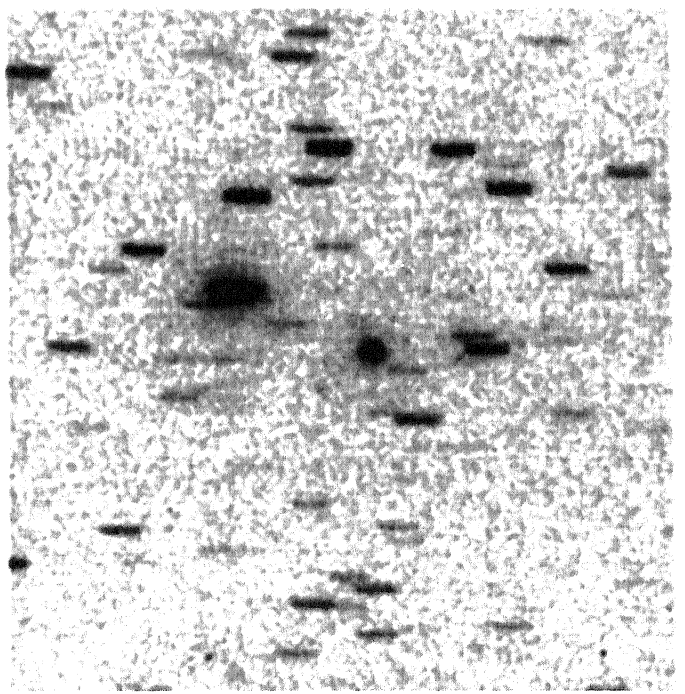


Figure 28. Field of an Indian satellite, imaged through the Himalayan Chandra Telescope. Integration time: 1 second.

Observations were carried out through the HCT using HFOSC in imaging mode on 27 January, 2003 and on 8th and 9th March, 2003 using the 1kX1k CCD of the Photometrics system in direct imaging mode. The images were acquired by switching off the drive of the telescope so that the Geo Stationary Satellites (GSS) are un-trailed and the stars are trailed (Figure 28).

Efforts are underway to improve the astrometric accuracy by obtaining the precise time of the exposures. This will yield a positional accuracy of the order of 100m in the sky plane position of the satellites.

(R. Vasundhara, C.G. Patil*, T.P. Prabhu and Team)

8. *Instrumentation and facilities*

UV detector calibration laboratory at IIA : A Class10000 clean-room has been designed and developed for UV detector calibration. Particle counts showed that the laboratory meets better standards than Class10000. The primary purpose of this laboratory will be to develop procedures for the calibration and characterization of UV instruments. An ultra-clean vibration isolation table has been installed. A vacuum Monochromator from Acton Research, USA and a photon counting 25mm detector with a CCD read-out (similar to the proposed flight detectors) from Photek Limited, United Kingdom have been installed. This CCD operates from about 1400Å to the air cutoff. Several filters and standard sources have also been procured for the calibration purpose. We will be studying the spectral response, sensitivity, geometrical distortions and flat-field mapping of the existing detector and also characterize the filters for UVIT. This will help us develop procedures for characterizing the space qualified flight detectors. A vacuum tank has been designed for vacuum UV tests. The necessary vacuum pumps have been procured. An optical bread-board set up with optics, optomechanics, computer controlled motion actuators etc. has been developed and tested.

(B. Raghavendra Prasad).

Mechanical Design Section

Following works were carried out by the Mechanical Design Section and Mechanical workshop at VBO Kavalur.

1.Gamma ray Telescope : Concept design, primary design calculations, technical specifications and optimization of requirements have been completed inhouse. Design analysis of the structure has been completed and detailed engineering is under progress. Fabrication work is expected to begin by June 2003.

2. Vacuum coating plant building at IAO Hanle : Design, detailed engineering and fabrication of Roof Truss have been completed at Bangalore. Truss has been sent to Hanle for installation. Truss will be erected once the building work is completed by early August 2003.

3. 75cm telescope at VBO Kavalur : Modification / redesigning of dome drive system and telescope mount is under progress. Design and detailed engineering of new dome drive assembly is completed; fabrication of new wheel assembly is under progress and will be completed soon. Telescope design work and design analysis is completed.

4. Mount for GPS: A modified GPS mount, compact in size was designed and fabricated. These mounts were sent to a few places in the country for the installation of GPS system.

(P.K. Mahesh)

Computer Center

A local area network consisting of about 180 nodes was set up in the Bangalore campus. A fibre optic backbone covers the entire campus and provides connectivity with various network switches spread over several buildings. The individual nodes are connected to the switch through CAT 5 cabling with 100 Mbps ethernet cards at each individual node. This has replaced the earlier coaxial cable based network, resulting in better reliability and faster intra and internet access.

A Sun Fire system with Dual processor 280 R operating at 900 MHz with 4 GB RAM with 2*36 GB hard disk operating under Solaris 5.8 has been installed for analysis of Image data at the Computer Center, Bangalore. This is part of the existing Sun cluster available currently.

1) LAN at Kavalur : A fiber optic based network is also being proposed to be implemented at Kavalur connecting various telescope buildings viz 2.34 m, 1.02 m, 75 cm and 22 cm. This will enable data acquired from all these facilities to be analysed and archived in a common data center.

2) Internet facility at Kavalur : The existing shared link between Bangalore and Kavalur will be converted to a 64K VSAT based connection to internet for Kavalur. This will be a dedicated 64 K satellite link provided by M/s ITI, Bangalore. This will permit such services as e-mail, web access from Kavalur.

3) Internet link to Kodaikanal : The existing equipment at Bangalore for dedicated Bangalore/Kavalur link will be relocated at Kodaikanal to provide a direct internet link to Kodaikanal for faster data and e-mail connectivity.

Developmental work at Kavalur

The 75 cm telescope at Kavalur is being modified to achieve better performance. The following aspects are under consideration:

1) A digital control based on Turbo-Pmac boards from Delta Tau Controls, USA.
2) Upgradation of mechanical elements of the telescope.
3) Upgradation of Dome and Shutter assembly and better electrical controls for their movements.
4) A 2K*2K CCD camera based on Cryo Tiger cooling as a backend.

The first phase of development includes independent control of all these sub systems. In the next phase it is proposed to have a client/server approach to control all these sub systems from a single user interface.

Most of the components required for controlling the telescope namely I/O interfaces, motors, encoders and limit switches have been procured. The dome and shutter assembly are being modified and dome movements are to be automated with AC motor drives.The mechanical design and analysis of the telescope structure is underway. Once the detailed design is over mechanical fabrication will begin.

The software for the 2K*2K CCD camera is almost ready. This is to work under Linux environment . The sensor is a 24 micron pixel SITE sensor. It is also envisaged that the sensor will be cooled by a Cryo Tiger mechanism instead of liquid nitrogen. However the performance of the Cryo Tiger is to be evaluated.

Improvements Envisaged for Kodaikanal Tunnel Telescope :

1) Installation of a manual coarse guider : This is a prelude to the proposed coarse tracker. The proposed coarse tracker is based on a quadrant detector sensor. This coarse compensation system will provide auto guiding on sun spots and limb.

2) Development of a fine tracker : A fine tracker based on correlation principle is also under development. The sensor is a CCD camera of 128*128. The correlation calculations are performed by a multi processor TI board.

HCT software :

The auto guider software working in the on-axis mode was made operational. However there was difficulty in operationalizing the auto guider in off-axis mode because of reliability problems with the auto guider camera movements. The system is still under testing. It is expected to be made operational in the

coming months. The EOS, Australia has also provided a user invocable library for incorporating observatory system related calls in user applications.

(A.V. Ananth)

Speckle interferometer :

The speckle interferometer is being used at the Cassegrain end of the 2.34 meter Vainu Bappu Telescope (VBT), Vainu Bappu Observatory (VBO), Kavalur regularly to record speckle-grams of certain objects, such as, close binary stars ($\rho < 1''$), active galactic nuclei. The newly acquired 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. Specklegrams of several binary systems have been recorded by employing this L3CCD; the quality of the data was found to be satisfactory.

The atmospheric coherence is a highly variable parameter depending upon the high velocity wind, it varies from < 1 msec to ~ 0.1 sec; the atmospheric parameters change very fast as well. Therefore it is essential to record a series of specklegrams as fast as possible. The drawback of this present L3CCD is its inability to store more than 10 frames (128 x 128) in a second. Efforts are on to procure a 512 x 512 L3CCD system with a 5/10 MHz card.

(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 L3CCD camera system as detector. Data analysis of a few close binary stars alongwith the respective reference stars are in progress. More than 400 frames of each of these stars are scanned carefully and are being used for analyzing. Reconstruction of these stars are in progress by using the triple correlation technique as well. The power spectrum, as well as the phase from the average bispectrum of the images of these stars have also been derived. 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 and L. Yeswanth)

Photonics Division

102 cm Telescope

The fabrication work on the 102 cm primary mirror of the 102 cm telescope has been completed. The existing 102 cm primary mirror was brought to Bangalore and complete tests were carried out in-situ. The Focault wire test, interferometric tests and Null tests were carried out and the results were obtained. The tests were done at the same place, with the same support systems and the same environment as that of the new mirror. The results of both the mirrors agree in tandem which confirms that the Zerodur mirror has been duplicated exactly as the old mirror. Both the mirrors have been shifted to Kavalur and aluminized. The new mirror was mounted on the telescope and aligned. A few trial images were obtained. Finetuning of the support system and other mechanical structure and realignment is necessary to improve the image quality.

Long Trace Profilometer (LTP) :

Project on Long Trace Profilometer (LTP) for measuring the slope errors / surface profile of long grazing incidence optics based on polarization shearing interferometer has been completed. The LTP is operational from June 2002. The accuracy and sensitivity of this instrument matches with the best elsewhere in the world. It is in continuous use for testing Synchrotron Beam Line Optics for the past one year.

A new project proposal to build an advanced and improved version of the Long Trace Profilometer (LTP - ver.2) has been submitted to BRNS. In principle it has been approved.

VHRR Sunshield Panels :

The development of sunshield panels for INSAT - 3D imager and sounder coolers is in progress. Better than 1000 class, two clean rooms for the work have been made ready. Special fixtures were designed to accommodate these large size panels. Work is on schedule.

Space Optics :

Astrosat : The photonics division continues to be a part of Ultra Violet Imaging Telescope (UVIT) - ASTROSAT (Indian Astronomy Satellite to be launched in 2006) team. Optical system design and realization of the optics is our responsibility. The optical configuration and design details have already been completed.

Vacuum And Thin Film Coating :

During this period a new setup for chromium and gold thin film coating on mirror substrates - a requirement for Synchrotron Beam Line mirrors, has been built and installed at the 1.6m vacuum coating plant at VBO, Kavalur.

The 30 cm coating plant at Bangalore, was extensively used to aluminize a number of small optics for various users in the Institute. The coating plant has been modified to provide a second coating on the substrate by introducing a secondary source inside the chamber. Experiments were conducted to provide aluminium and MgF coating and chromium and gold coating on glass substrates.

The Photonics Division had participated in designing and monitoring the manufacture of the 2M vacuum coating plant for Hanle, which has

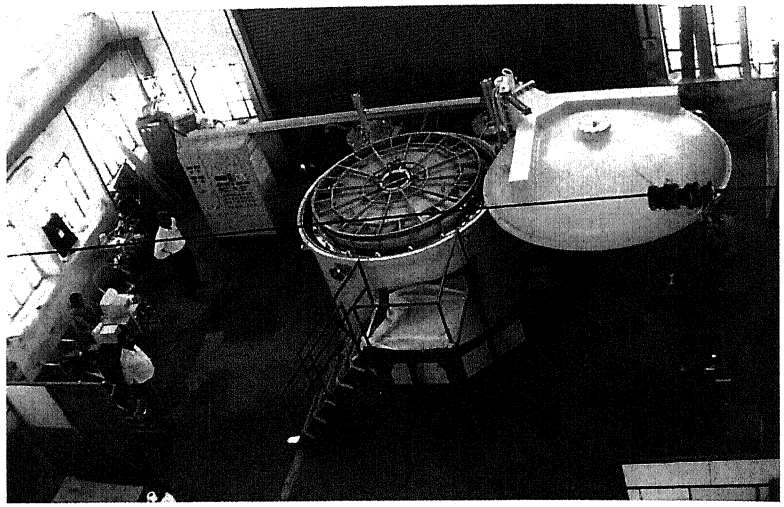


Figure 29. 2M Vacuum Coating Plant for Hanle undergoing tests at Hind High Vacuum Co. Bangalore.

to withstand extreme temperature (-30 to +30° C) and climatic conditions prevailing at Hanle (Figure 29).

Adaptive Optics :

The Division is spearheading a group on Adaptive Optics in the Institute. Research is directed towards building a low cost adaptive optics system for astronomical applications. Using a Shack Hartmann sensor and CMOS detector, a laboratory model has been successfully built. Efforts are on to reduce the closed loop timing to within 20 millisecs. Research work is in progress to build a new wavefront sensing using polarization shearing interferometric technique which is already established. The aim is to compute the phase using a single record. The approach is to build a history and compute the change in errors from the closest match for adaptive corrections.

They continue to interact with other Adaptive Optics groups working in the country such as IRDE, Dehradun and Udaipur Solar Observatory.

(A.K. Saxena)

Library

Christina Birdie was awarded the prestigious International SLA award the "Diversity Leadership Development Program" for the year 2003. This award is given to individual librarians, who are from multi-cultural background, and who have demonstrated leadership qualities within the association.

The Library added 450 books and subscribed to 199 journals, 2 new journals were added this year, 77 of these can be accessed electronically. 459 journals were bound during the year. The library responded to 230 interlibrary requests. IIA library started accessing the journal "Nature" online from August, 2002, through the FORSA consortium arrangement. The library continues to develop the book and journal collection for the CREST library.

The Library organized a photo exhibition during the celebration of M.K.V. Bappu's 75th birth Anniversary. Some rare photographs were displayed at this exhibition.

A national level Round Table Meeting on "Consortia Models in Indian Libraries" was also organised at IIA during the 28 and 29th November 2002. Sixty librarians from different science and technology libraries all over India, and many publishers and vendors were invited for this two day discussion meeting.

(A. Vagiswari)

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 part 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 place annually in the month of February at several centers distributed over the country. Based on the performance in JEST and the preference of the candidates, a limited number of them are interviewed. The successful candidates in the interview are offered Junior Research Fellowship (JRF) position. The programme commences in August each year.

IIA Entrance Exam : Students are selected after undergoing an entrance test in the month of November 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 five member institutes. JAP students have the option to join IIA after the first year of course work.

Summer Project Programme : The students who are selected for IIA summer project programme have the opportunity to write the entrance test for IIA Ph.D. programme in the month of June. Based on the performance of the students, a few of them are interviewed and preselected for IIA Ph.D. programme. The selected students have the option of joining IIA immediately after the completion of the degree.

Currently there are 25 full time Ph.D. students working on a diverse range of problems.

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. Presently, 2 members are registered for their Ph.D. degree.

Student information handbook : A handbook on IIA Ph.D. programme is prepared. This book gives the information on stipend, tenure, benefits and privileges, responsibilities and obligations, of the students. The course curriculum and explanation of the grading system can also be found in the booklet.

Course work

All students are required to undergo course work for 2 semesters in the first year. Currently IIA is following JAP course work. Furthermore, the students have 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 photosphere and 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; Investigation of dust from comets.

Stars and Stellar Systems : The various topics in this area are: Studies of interstellar 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 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 nonlinear optics; Torsion balance investigation of the Casimir effect.

Award of Ph.D degree :

S.G.Bhargavi was awarded the Ph.D. degree by the Mangalore University for her thesis titled "Investigation into the nature of the sources associated with the gamma ray burst (GRB) phenomenon", under the supervision of R.Cowsik.

R.Sridharan was awarded the Ph.D. degree by the Bangalore University for his thesis titled "Techniques for achieving higher spatial resolution", under the supervision of P.Venkatakrishnan.

Nagaraja Naidu was awarded the Ph.D. degree by the Bangalore University for his thesis titled "Mosaic CCD camera system - Implementation and application to Astronomical imaging", under the supervision of R.Srinivasan.

Dharam Vir Lal was awarded the Ph.D. degree by Indian Institute of Science for his thesis titled "Seyfert galaxies: Nuclear radio structure and unification", under the supervision of Prajval Shastri.

Students' Training Programme

As a part of the outreach programme, the Institute conducts various student training programmes. Under Summer project student 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 2002-03, 10 students participated in this programme.

(Vinod Krishan)

Conference reports

Sun, Stars and the Extragalatic Universe

A national symposium entitled 'Sun, Stars and Extragalactic Universe' was organised from 8 to 10th August 2002 to celebrate the 75th birth anniversary of the founder Director of IIA, the late Prof. M.K.Vainu Bappu. It was a well attended meeting with participation from several research institutions as well as universities. The symposium was held each day at a different centre of IIA, starting at CREST (Hosakote), at the main campus (Koramangala) with a concluding session at VBO (Kavalur) giving an opportunity for the participants to see the facilities at these centres. The inaugural session was hosted in the CREST campus with Prof.M.G.K. Menon, founder chairman of the governing council of IIA and an Honorary Fellow, as the chief guest. He gave a memorable talk on Prof. Bappu -the man, his accomplishments, hopes and dreams in his inimitable style laced with dates, names and events. The concluding session at VBO Kavalur was held on the observing floor of Vainu Bappu Telescope. Prof. Cowsik highlighted the role of Prof. Bhattacharyya in completing the VBT particularly after the untimely demise of Prof. Bappu.

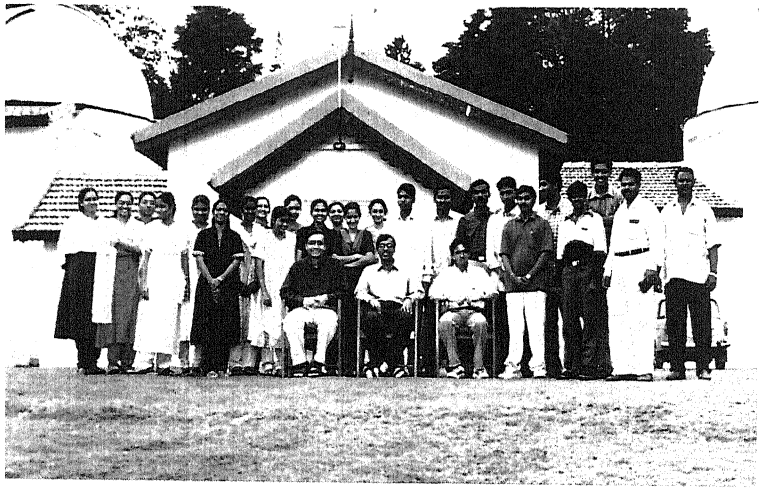
Prof. Bhattacharyya recalled the events that led to the conception and the realisation of VBT. A video film depicting some of the events with Bappu at Kodaikanal and Kavalur was presented by Prof R C Kapoor. It was particularly significant that Astronomical Society of India chose the occassion to present the Vainu Bappu Gold Medal for the year 2000, to Dr. Biswajit Paul of TIFR. Dr. Paul gave his award talk 'A study of microquasars and pulsars with Indian x-ray Astronomy Experiment'. There also was a delightful session of reminiscences when several former students and colleagues of Prof.Bappu recalled their association with him. The final event that evening was the inauguration of the Fiberfed Echelle Spectrometer to the VBT located at the coude lab by Prof. B.V. Sreekantan. Prof. N. Kameswara Rao described the long awaited instrument that feeds the star light from prime focus to the high resolution spectrometer situated in the coude laboratory.

The series of invited talks highlighted some of the emerging astronomical facilities in the country (eg. Himalayan Chandra Telescope, GMRT, ASTROSAT, USO, development of mosaic CCDs etc.) as well as areas where Prof. Bappu had some special interest or had contributed. These covered solar physics, stars, extragalactic astronomy and cosmology and instrumentation and facilities. The invited speakers included S.M.Chitre, S.S.Hasan, J.Singh, R.Ramesh, R.Vasundhara in the area of solar physics and solar system, D.L.Lambert, K.E.Rangarajan, M.Parthasarathy, C.Sivaram, Ram Sagar, B.N.Dwivedi in the area of Stellar Physics, Chanda Jog, S.Ganesh, D.Bhattacharya, R. Srianand, A. Mangalam, D. Narasimha, R. Cowsik in the area of extragalactic astronomy, R. Nityananda, T.P.Prabhu, R.Srinivasan, N.Kameswara Rao, P.C.Agrawal, P. Venkatakrishnan in the area of Instrumentation and Facilities.

It was heartening to see the participation of large number of not only the present members of the Institute but also the earlier and retired members. The symposium was organised as a celebration and a delightful music concert by Kadri Gopalnath and party on saxophone made it indeed as one.

(N. Kameswara Rao)

Kodaikanal Summer School in Physics : A summer school on Classical Mechanics, Nonlinear Dynamics, Electrodynamics and Special Relativity was conducted at the Indian Institute of Astrophysics, Kodaikanal, during June 03-20, 2002. A total of twentytwo final M.Sc., and B.Sc. Physics students were selected on an all-India basis to attend the course. The enrichment course comprised of lectures and tutorials. The lectures were given by Professors Vasanth Natarajan, V. Venkatraman, G. Rangarajan, IISc., Bangalore; and Sushant Datta Gupta, S.N. Bose, National Centre for Basic Sciences, Kolkata. The tutorials were conducted by Dr. Sourish Basu and Dr. Prashant Srinivasan, IISc., Bangalore. During the school, Professors V. Rajaraman, IISc., Bangalore and T.P. Prabhu, IIA, Bangalore gave evening public lectures on "Trends in Information Technology" and "Astronomy from the World's Highest Telecope" respectively.

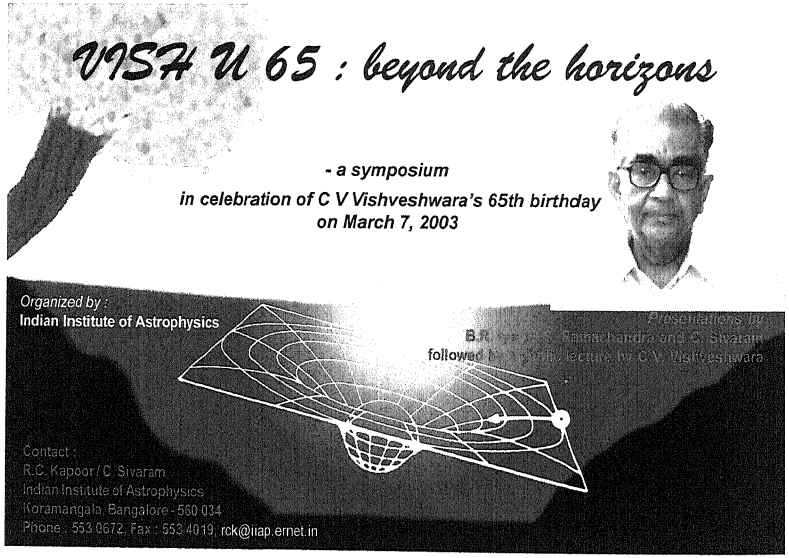


Summer school students and the course lecturers.

(S.S. Gupta)

VISH'U 65

On March 7, 2003, a function was held at the Institute to celebrate Prof. C.V. Vishveshwara's 65th birthday. The occasion was aptly dubbed Vish'U 65 to convey warm regards to one of our seniormost and most revered scientists. There was a three hour long scientific session in which four talks were presented covering various areas of general relativity in which Vishu had made notable contributions. The opening talk by C. Sivaram gave an overview of the developments in black hole physics since the time Vishu made his key contribution on the stability of the Schwarzschild black hole and predicted quasi-normal modes. This is of much interest today in various proposed set ups to detect gravitational waves (from coalescing binaries, binary black holes etc), topic discussed by B.R. Iyer. Vishu himself gave a lucid account of his current work on black holes in cosmological backgrounds which was further elaborated on by B.S. Ramachandra, Vishu's student whose thesis is on this topic. As a fitting finale, there was an evening lecture on Bees, Bubbles and Black holes, by Vishu himself who thrilled a large audience in his usual inimitable style. The poster was designed by R.C. Kapoor and Richa Kapoor*.



(C. Sivaram and R.C. Kapoor)

National developments

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).

McDonnell 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 greenhouse gases concentration at Hanle, and inverse modelling of global fluxes'.

Collaboration in teaching

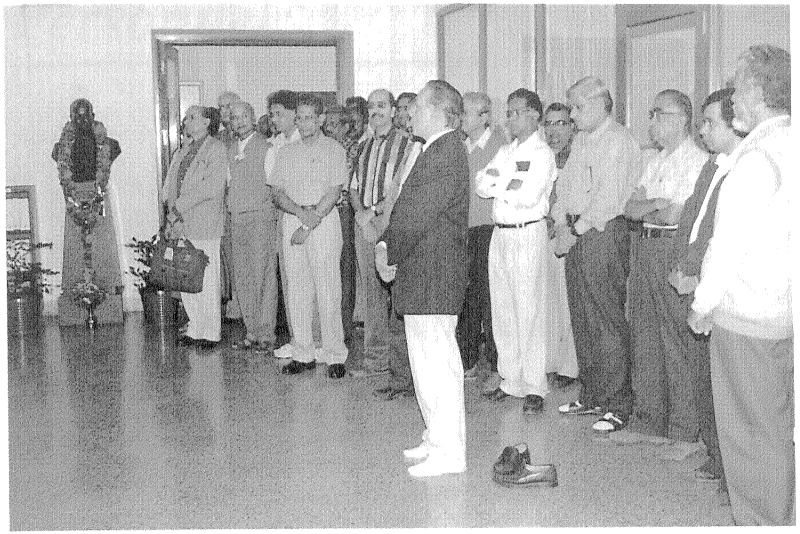
IIA is an active partner in the Joint Astronomy Programme (JAP) at IISc since its inception in 1982. 15 students from this programme have pursued their doctoral work under the supervision of scientists from IIA.

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

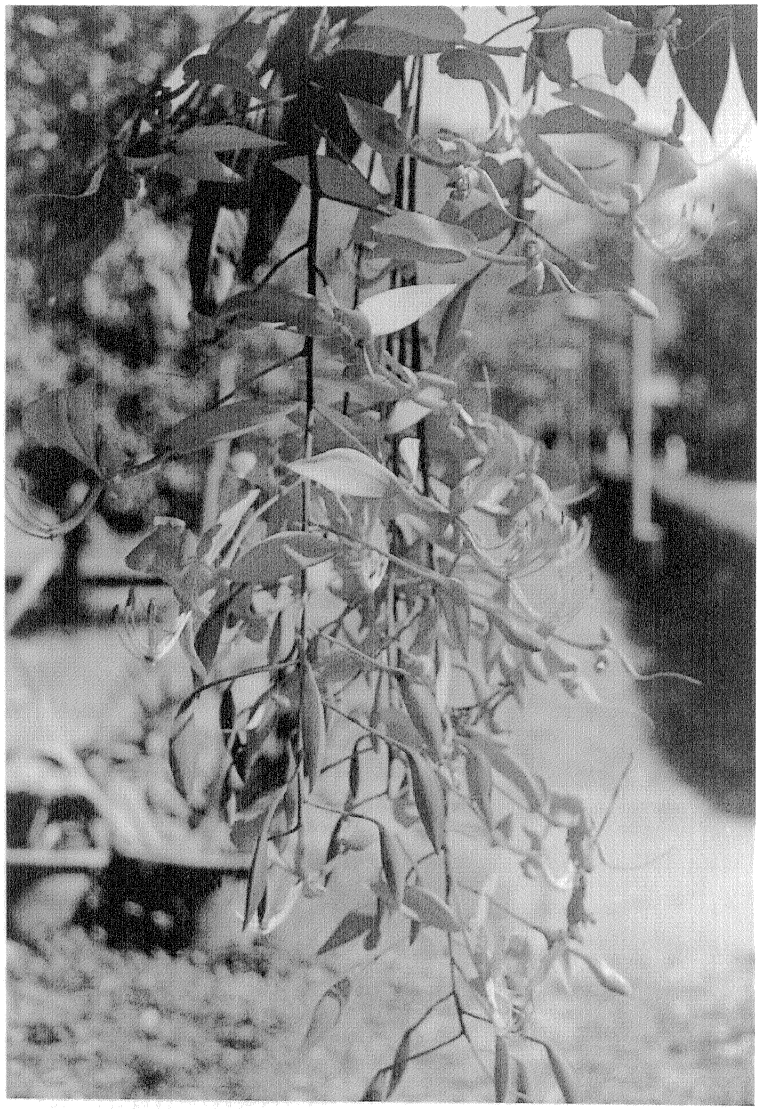
A major part of the activities of the Astronomical Society of India continued to be centred at the Institute with A.K. Pati as the Secretary of the ASI and Harish Bhatt as the editor of the Bulletin, ASI. D.C.V. Mallik is the Chairman of the Scientific Organizing Committee for ASI meetings for a period of three years.

Indian Institute of Astrophysics, Bangalore Campus



M.K.V. Bappu's birthday celebration, August 2002.

Saxophone recital by Kadri Gopalnath (centre) and party, 8th August, 2002.



The flowers of the Tree of Heaven (*Amherstia nobilis*), I I A Bangalore campus.

Personnel

Academic / Scientific / Technical Staff as on 31.3.2003 includes the following :

Director : Ramanath Cowsik

Senior Professor : B.P. Das, S.S. Hasan, N. Kameswara Rao, M. Parthasarathy, T.P. Prabhu, J.H. Sastri, R. Srinivasan, Vinod Krishan,

Professor : R.C. Kapoor, D.C.V. Mallik, Jagdev Singh, C. Sivaram

Head Photonics : A.K.Saxena

Sr.Principal Scientific Officer : A.V. Ananth

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

Librarian : A.Vagiswari

Associate Professor II : Jayant Murthy

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

Associate Professor : P. Bhattacharjee, K.N. Nagendra, K.R. Subramanian, Sunetra Giridhar, S. Surendra Gupta, R Vasundhara

Scientist D : G.C. Anupama, S. Chatterjee, R.K. Chaudhuri, P.K. Das, R. Kariyappa, S.G.V. Mallik, M.V. Mekkaden, S. Mohin, P.M.S. Namboodiri, K.P. Raju, K.E. Rangarajan, S.K. Saha, R. Surendiranath,

Sr.Research Scientist : B. Raghavendra Prasad

Principal Scientific Officer : V. Chinnappan

Engineer D : G. Srinivasulu

Scientist C: B.C.Bhatt, A. Goswami, U.S. Kamath, J. Javaraiah, Prajval Shastri, K.B. Ramesh, A. Satyanarayanan, R. Ramesh, D.K. Sahu, Sujan Sengupta, M. Srinivasa Rao, A. Subramaniam, K. Sundara Raman

Scientist : K.M. Hiremath

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

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

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

Engineer C : V. Armugam, S.S. Chandramouli, Faseehana Saleem, P.K. Mahesh, S. Narayanan, J.S. Nathan, B. Ravikumar, M.P. Singh, S. Sriram

Asst. Librarian C : Christina Birdie

Scientist B : B.S. Nagabhushana

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

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

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

Engineer (Civil) : R. Ramachandra Reddy

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

Documentation Officer : S. Rajiva

Tech. Associate B : F. Gabriel, K. Jayakumar, Joseph Rosario, K. Kuppaswamy, G.N. Rajasekhar, A. Selvaraj, N. Sivaraj, K.S. Subramanian

Technical Associate : P. Anbazhagan, A.S. Babu, E.E. Chellasamy, P.U. Kamath, K. Rangaswamy, G.S. Suryanarayana, Tsewang Dorjai, A.V. Velayuthan Kutty

STA B : C. Nanje Gowda, Narasimhappa

SMA B : A. Mani

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

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

Visiting Sr. Professor : G. Ramachandran, P.R. Vishwanath

Visiting Fellow/PDF : S.G. Bhargavi, S.K. Muneer, P.S. Parihar, Kiran Jain, Chiranjib Sur

SRF : S. Ambika, R.K. Banyal, G. Gauba, M. Gopinath, C.Kathiravan, P. Kharb, K.V.P. Latha, Malay Kumar Nayak, P. Manoj, Rajalakshmi, B.S. Ramachandra, B.K. Sahoo, P. Shalima, G.A.S. Sundaram

JRF : Ankur Chaudhari, J. Baliga, Malay Maiti, K. Nagaraj, 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

G.C. Anupama attended the Euroconference "Symbiotic Stars Probing Stellar Evolution" held in La Palma, Spain, during 27–31 May 2002, and gave an oral presentation on "Spectroscopic Monitoring of Symbiotic Stars from the Vainu Bappu Observatory". She also attended the 22nd Meeting of the Astronomical Society of India held in Pune, during 2003 Feb 13-15 and presented 4 poster papers.

S.P. Bagare attended the XXII meeting of ASI, Feb 13-15,2003 in Thiruvananthapuram and gave an invited oral presentation on Report from Observatories - Kodaikanal Observatory.

H.C. Bhatt attended the XXII ASI Meeting at Thiruvananthapuram, 13-15 February, 2003.

S.G. Bhargavi gave the following talks :'Observing the GRB remnants' at MPE, Munich, Germany 2 Sept 2002; 'Afterglows of Gamma Ray Bursts' at C. N. R. Bologna, Italy, 6 Sept 2002 ; 'Gamma Ray Burst in the afterglow era': 3rd workshop 17-20 Sept 2002 held at C. N. R. Rome, Italy; 'Luminosity functions clustering of GRBs' at Trieste Observatory, Italy, 24 Sept 2002 ; 'Afterglows of Gamma Ray Bursts' at Granada Observatory, Spain, 26 Sept 2002 ; 'Gamma Ray Bursts' at Raman Research Institute, Bangalore, 25 Oct 2002.

P. Bhattacharjee gave a seminar on "Origin of the Post-GZK Cosmic Rays: Some remarks on the Top-Down scenario" – Theoretical Astrophysics Seminar at Fermilab, USA, Monday 13 May 2002.

P. Bhattacharjee attended the DAE High Energy Physics Symposium held at Jammu University, Jammu, 11–15 November 2002 and gave an invited talk, attended the International, *Particles, Strings and Cosmology* (PASCOS-03) Conference held at TIFR, Mumbai, 3–8 January 2003, and gave an invited parallel session talk. He attended the 22nd Meeting of the Astronomical Society of India (ASI) at Thiruvananthapuram, February 13–15, 2003, and presented a poster.

Christina Birdie attended the 93rd SLA (Special Libraries Association) conference at Los Angeles and 23rd IATUL (International Association of Technological University Libraries) at Kansas city in the month of June 2002, and presented a paper.

R. Gangadhara attended the International Conference on Plasma Physics and Technology, Dec. 9-14, 2002, Bangalore, and presented a poster on "Centrifugal acceleration of plasma in pulsar magnetosphere". He also attended the JAP 20th year meet during Oct. 3-5, 2002 held at Indian Institute of Science, Bangalore, and gave a talk on the 'Understanding emission geometry of PSR 0329+54'.

S. Giridhar attended a symposium 'Beyond the Horizons' held on March 7, 2003 in celebration of 65th birthday of Prof. C.V. Vishveshwara. S. Giridhar also attended the symp. on Sun, Stars and the Extragalactic Universe, held at IIA during Aug 8-10, 2002.

S.S. Hasan attended the following meetings : American Astronomical Society Meeting, Albuquerque (U.S.A.), June 2- 6, 2002 and gave an invited review on: Dynamics of the Quiet Chromosphere; Sun, stars and the extra-galactic universe : In celebration of M.K.V. Bappu's 75th birth anniversary, Bangalore, Aug. 8-10, 2002 and gave an invited review Structure and Dynamics of the Solar Atmosphere

K.M. Hiremath attended the following conferences : IAU coll. 188. "Magnetic Coupling of the Solar Atmosphere", June 11-15, 2002, Santorini, Greece and presented the paper "Long period global quiet coronal oscillations"; IAU Symp. 210, "Modelling of Stellar Atmospheres", June 17-21, 2002, Uppasala, Sweden and presented the following paper "Steady parts of magnetic field and rotational velocity field structures in the atmosphere of late type stars".

Jagdev Singh participated in the COSPAR meeting and presented a paper, 'Variation in the network flux as derived from the calcium K-line profiles as function of latitude and solar cycle phase', in the Solar cycle and climate change meeting held at Houston, USA during Oct 10-19, 2002.

J. Javaraiah attended the XXII Annual Meeting of ASI, February 13 - 15, Thiruvananthapuram and presented a paper entitled, "1.3-Year' and '153-day' periodicities in the Sun's surface rotation". He also attended the DST project adversary committee (PAC) meeting on Physics Astrophysics, March 28, 2003 and made a presentation on a project proposal for the DST Indo-Bulgarian scientific cooperative programme. Javaraiah also attended the Workshop on "Reservation policy for SCs/STs/OBCs in PSU's" from 7th to 9th April, 2003, held at Hotel Atria, Bangalore.

Vinod Krishan attended the workshop on "Plasma Astrophysics " - Astrophysical Flaws" during Nov 9-22,2002 ICTP, Trieste, Italy; Annual meeting of the Brazilian Astronomical Society, Joanapolis, Brazil Aug 29,- Sept 2, 2002; Twenty years of JAP, Oct, 2002. I.I.Sc Bangalore.

A. Mangalam delivered 6 lectures and tutorials on topics in Kinetic theory, Violent Relaxation, and Non-linear collapse at high redshift at a SERC school on "Cosmology and Large Scale Structure", held at IIT, Kharagpur, in the month of June 2002. A. Mangalam also participated in the eigth discussion meeting on a frontier area of research, "Astrophysical and Geophysical Fluid Dynamics", held by the Kumari Meera Memorial Trust at Center of Learning, near Bangalore during 3-7 January.

T.P. Prabhu attended the XXII meeting of Astronomical Society of India, Thiruvananthapuram, February 12-16, 2003, and made an oral report on the 'VBO and IAO facilities'.

S. Mallik attended the IAU Symposium 215 on 'Stellar Rotation' held in Cancun, Mexico during Nov.11-16, 2002 and gave an oral presentation on 'Lithium and Rotation in Pop.I stars'.

J. H. Sastri participated in the I-STEP sponsored workshop on "Dynamical coupling in equatorial Atmosphere-Ionosphere System", held in Tirunelveli during May 2-3, 2002.

A.K. Saxena attended "Asia Interfinish 2002" International Conference on Electroplating and Metal Finishing, on Nov.19 - 21, 2002, NewDelhi.

S. Sengupta gave a seminar at IUCAA titled 'Polarization from brown dwarfs: Theoretical prediction and observational confirmation'.

C. Sivaram Astrophysical , Geophysical and Atmospheric Fluid dynamics . Discussion meeting organised by Kumari L. A. Meera Memorial Trust , Centre for Learning Bangalore, Jan 3 to 7 , 2003. SERC School on " Precision Spectroscopy of Atoms, Molecules and Bose condensate , IISc Bangalore March - 2003. International Symposium on Science and Beyond. NIAS Bangalore Jan 8 - 11, 2003.

M. Srinivasa Rao attended the international conference on "Stellar Atmospheric Modeling" held in Tuebingen, Germany during the period April 8 - 12, 2002 and gave a oral presentation in the meeting on " Reflection Effect in Close Binaries".

A. Subramaniam attended the XXII ASI Meeting, held at Thiruvananthapuram, and presented three poster papers. 1. Warp in the LMC? - A. Subramaniam, 2. The local stellar population around slow nova regions in the SMC - A. Subramaniam and G.C.Anupama. She also attended the "UVIT Science and filter definition", held on 27 and 28 of March 2003, at IIA, Bangalore and gave a talk titled "Globular clusters: galactic and extra-galactic" at the meeting.

Chiranjib Sur attended a workshop on "Parallel Computing in the Physical Sciences", IISc, in March 2003.

A. Vagiswari and Christina Birdie attended the Library and Information Services in Astronomy IV (LISA IV) conference held at Prague in July 2002.

Vagiswari chaired a session on issues relating to developing countries. Christina Birdie presented a paper on the "Future of Consortia among Indian Libraries."

Invited Talks at Conferences, seminars, workshops.

G.C. Anupama attended the International Meeting "Classical Nova Explosions" held in Sitges, Spain during May 20-24, 2002 and gave an invited Review talk "The Recurrent Novae and Their Relation with Classical Novae".

H. C. Bhatt visited the State Observatory, Nainital and gave a talk on "Circumstellar disks around Young Stellar Objects", 20 May, 2002.

P. Bhattacharjee gave the following talks : Origin of UHE Cosmic Rays: Probing Physics Beyond Standard Model – DAE High Energy Physics Symposium, Jammu University, Jammu, 11–15 November 2002; Current Topics in High Energy Astrophysics & Astroparticle Physics – A set of six invited lectures given as a part of the UGC Refresher Course at Assam University, Silchar, Assam, December 9–14, 2002; Ultrahigh Energy Cosmic Rays and Prompt TeV Gamma Rays from Gamma Ray Bursts – Invited parallel session talk given at the International PASCOS-03 Conference held at TIFR, Mumbai, January 3–8, 2003.

R. Chaudhuri gave an invited talk on "Distributed Parallel Computing for Physicists" held during 11-19 th April 2002 in Harish-Chandra Research Institute, Trends in Theoretical Chemistry - 2002 (TTC-'02) held during January 17 - 19, 2003 in the Indian Association for the Cultivation of Science, Jadavpur, Calcutta. He also gave a talk on the parallel computing held during March 27 to March 30, 2003 in JNCASR in Bangalore.

B.P. Das gave the following invited talks : Recent developments in theory of parity nonconservation in atoms, International workshop on symmetries in atomic and nuclear physics, Seattle, USA (October-Novemeber 2002), Relativistic and correlation effects in atoms, Conference on Trends in Theoretical Chemistry, Kolkata (January 2003). Role of many-body theory in testing the Standard Model of particle physics, University of California, Berkeley, USA, November 2002.

S. Giridhar attended the 'Twenty years of Joint Astronomy Program', symposium held at IISc during Oct 3 – 5, 2002, and was invited to give a presentation on Late Prof. M.K.V. Bappu.

Jagdev Singh gave an invited talk, 'Spectroscopic studies of solar corona during eclipses and with coronagraph', at the 22nd ASI meeting held at Trivandrum, India.

Vinod Krishan gave invited lectures at ICTP, Trieste, Italy. Nov 14, 2002, On Structure formation in Turbulent media ; Fine structures in solar decimetric emission in the meeting 20 years of JAP, I.I.Sc., Bangalore Oct.2002.

A. Mangalam participated in National Symposium held in honour of Prof. M. K. V. Bappu at IIA on his 75the Birthday, 8-10 August, 2002 and gave an invited talk on "Aspects of Formation of Massive Black Holes". He also gave an invited talk at the JAP 20 meeting on "Constraints on Mass Spectrum of Supermassive Black Holes", at IISc Bangalore, 4-5 October, 2002 ; Invited talk on "Physics of Supermassive Disks"at the ASI meeting in Thiruananthapuram during February 2003. A. Mangalam also gave a talk at IUCAA, Pune during January 2003.

S. Mallik attended the XXII ASI meeting held in Thiruvananthapuram in Feb.13-15, 2003 and gave an invited talk on 'Lithium in stars on the main sequence and beyond'.

K.N. Nagendra delivered an Invited Review talk "Numerical methods for the solution of polarized line transfer equations", at the "3rd International Workshop on Solar Polarization (SPW3)", held in Puerto de la Cruz, Tenerife, Spain, during Sept. 30–Oct. 4, 2002. At a landmark workshop called "Stellar Atmospheric Modelling" in Tuebingen, Germany, during April 8-12. Nagendra delivered an Invited keynote address "Solutions of Polarized Line Transfer Equations" at this Conference.

T.P. Prabhu gave invited talks on 'Galaxies' in the astronomy workshops held at M.P. Birla Institute of Fundamental Research, Bangalore, in June 2002 and September 2002. He also gave invited talk on 'Astronomy from the World's Highest Telescope' at the Kodai Summer School in Physics, during June 2002, and on 'Indian Astronomical Observatory, Hanle' at TECHFEST, IIT (Mumbai), in February 2003.

B. Raghavendra Prasad gave an invited talk on "Optical Memories". DST Expert Group Meeting on "Molecular Electronics, conducting polymers, Non-invasive and other bio-sensors". 10-11 February 2003, National Physical Laboratory, New Delhi.

K.E. Rangarajan gave an Invited Review talk on 'Ground based Radiometric technique in remote sensing' in the XXII ASI meeting held in Thiruvananthapuram, Feb., 2003.

J. H. Sastri gave a review talk on ' Dynamical coupling in the low latitude Upper Atmsophere' in the I-STEP sponsored workshop on "Dynamical coupling in equatorial Atmospher-Ionsophere System", held in Tirunelveli during May 2-3, 2002.

C. Sivaram "Stars of very large and very low masses - Some subtle aspects of the physics": Invited lecture at the National Symposium on Astrophysics : Sun, Stars and the Extragalactic Universe : (In celebration of 75th birth Anniversary of Prof M.K.V Bappu), Aug 8 -10, 2002. "The Cosmological constant - Then and now" Invited lecture at "20 years of JAP (Joint Astronomy Programme)" Symposium , at I.I.Sc Oct 3 - 7, 2002. "The Solar Neutrino problem and its resolution" - Discussion meeting on the 2002 Physics Noble Prize (Xray and neutrino astronomy), 9 Oct,2002. Thirty - Five years of black holes : problems and Highlights Symposium Vish U 65: Beyond the Horizons (In celebration of Prof. C.V. Vishveshwara 's 65th birthday) : 7 March 2003. "CMBR Distortions and constraints on particle physics and chemistry" Neighbourhood astronomy meeting on WMAP results 2003. "Axion detection using atomic physics" Invited talk at SERC School on " Precision Spectroscopy of Atoms, molecule and Bose condensate" 4 March 2003.

Chiranjib Sur delivered the following talk : "On the theroy of angular correlation between photo - and Auger - electron ejected in double photoionization of atoms and the role of the detecting equipments" on January 6, 2003 in the 90th session of the Indian Science Congress held at Bangalore.

Positions and Fellowships

Since 1994 **K.N. Nagendra** is a visiting Professor of the Observatoire de la Cote d'Azur, Nice, France. He continues to hold that position for the 9th consecutive year.

J. H. Sastri, Visiting Professorship at The Solar-Terrestrial Environment Laboratory (STEL), Nagoya University, Toyokawa, Japan from December 2002 through March 2003.

Book Reviews

Bhatt H C, (2002) BASI, 30, 517. Distant Wanderers: The Search for Planets Beyond the Solar System (by Bruce Dorminey, Copernicus Books, Springer-Verlag, 2002).

Chatterjee S, Introduction to Electrodynamics by A.Z.Capri and P.V.Panat, Narosa, New Delhi, 2002 appeared in Resonance, 8, 94 (2003).

Visits

G. C. Anupama visited NCRA, Pune, 2002 August 19–25, 2002 September 23–26, 2003 March 17–25. She gave a Seminar "The parent population of novae in the LMC" on August 24, 2002. She also visited, TIFR, Mumbai: 2002 September 27–28 and gave a Seminar "The parent population of novae in the LMC" on August 27, 2002.

P. Bhattacharjee visited Univ. of Chicago and Fermilab, USA, during May 1–31, 2002, He gave the Theoretical Astrophysics Seminar at Fermilab, 13 May 2002 on: "Origin of the Post-GZK Cosmic Rays: Some remarks on the Top-Down scenario".

B.P. Das visited University of Washington, Seattle as Visiting Scholar in October - November 2002. He also visited University of California, Berkeley, during November 2002.

R.T. Gangadhara visited NCRA, Pune, and made pulsar observations during January 24-30, 2003.

S.S. Hasan visited the Harvard-Smithsonian Centre for Astrophysics, Cambridge, U.S.A. (May-June 2002); Paris Observatory, Meudon, France (October 2002), Institute for Theoretische Astrophysik, Heidelberg (March 2003).

J. Javaraiah visited de l'Observtoire, de la Cote D'Azur, Grasse, France, as a guest in the service of an Assistant Astronomer, 1st class, to work with Dr. J. P. Rozelot, on the problem, "Whether the Sun's magnetic waves are a possible explanation of the Sun's shape changes ?".

R. Kariyappa visited National Astronomical Society of Japan, Tokyo, Japan for 3-months (August 1 - October 31, 2002) as a Visiting Professor for a collaborative research with Professor Tetsuya Watanabe. He gave a seminar on "Preliminary Results on Intensity Oscillations in Coronal X-ray Bright Points from Yohkoh SXT Observations in September, 2002 and a Colloquium on "CaII K Imaging to Understand the UV Irradiance Variability" on October 25, 2002. He also visited Department of Physics and Astronomy, Kyoto University, Kyoto, Japan during October 28-29, 2002 and gave a talk on "Contribution of Chromospheric Features to UV Irradiance Variability". R. Kariyappa visited the Institute of Space and Astronautical Science (ISAS), Japan during September 1-30, 2002 and gave a seminar on the "Oscillations in Coronal X-ray Bright Points".

S. Mallik visited University of Maryland, U.S.A. during Nov.17-Nov.28, 2002 to continue collaborative work with Suchitra Balachandran on 'Li in stars of the alpha Persei cluster'.

K.N. Nagendra visited Observatoire de Nice, France, for two months during August-September, 2002, to continue ongoing collaboration. He continued the discussions and collaboration on several problems of polarized line transfer theory with French, and Swiss scientists. He also visited University of Tuebingen, Germany (April 2002); Institute of Astronomy, Tuebingen, Germany (April 2002); Flomerics Ltd. (Fluid dynamics software research center); Filderstadt, Germany (April 2002); Visited THEMIS and VTT telescopes at Teide Observatory, Spain (October 2002).

M. Srinivasa Rao visited the Astronomical Institute, Academy of Sciences of the Czech Republic for a week long time and presented a talk on " Atmospheres of the components in a close binary stars" and gave a brief description about our Institute's projects. Later he had discussions with Dr Jiri Kubat about possible collaboration on the stellar wind problem.

R.Vasundhara visited L'Institut de mechanique celeste et de calcul des ephemerides, Paris, during October - December 2002 and the Max-Planck-Institut fur Aeronomie at Katlenburg, Lindau during Nov. 16-19, 2002.

Teaching/Guidance activity

G. C. Anupama taught Observational Astronomy - I (Optical astronomy) course in the JAP Course Work (2002 October–November). She also served as resource lecturer at the Summer School in Astrophysics conducted by the M.P. Birla Institute of Fundamental Research, in April 2002. Served as a resource lecturer at the 100-hrs Certification Course in Astrophysics conducted by the M.P. Birla Institute of Fundamental Research, in September 2002.

S.P. Bagare taught course in solar physics as guest faculty at the Department of Physics, Bangalore University. Served as Member, Board of PG exams in Physics, BUB. Thesis supervisor to Mr. Rabbi Angiras who registered for Ph.D. with BUB during the year. Mr. Angiras is working on the missing flux problem in sunspots. Co-guide to Mr. K.Balachandra Kumar who registered for Ph.D. with the Madurai Kamaraj University during the academic year. Mr. Kumar is working on transition probabilities of molecular species observed in sunspots.

S. Chatterjee was invited by the Indian Statistical Institute, Bangalore Centre to develop experiments on electricity and magnetism, for the B.Math students(2003). He taught a 12-lecture course on Galactic Physics at the UPSO, on invitation in June-July 2002.

S. Chatterjee with Dr. K.Rajendra Udupa , supervised the B.E. project for the final year students of the Department of Metallurgy, National Institute of Technology, Surathkal. The project entitled, " Assessment of the surface oxidation of molten aluminium and aluminium- silicon bases alloys using laser as probe," undertaken by Mr.Atul Vishal and Ms. Preethi, was adjudged the best project in the department for the year 2002-03.

R.T. Gangadhara guided Ms. Sanghamitra Deb, (M.Sc. student from IIT, Kanpur)for her project on the "Acceleration of particles in pulsar magnetosphere". He also taught a course on Plasma Physics for the final year M.Sc. students at the Dept. of Physics, Bangalore University, from the period January to March 2003.

S. Giridhar guided a summer school student Siddartha Gautam with his project on spectral classification of VBT survey stars during May - June 2002. She also guided another student Vijay Shankar Reddy with his project on 'Performance Tests of VBT Echelle Spectrograph' during May - Aug 2002. Giridhar was invited to review a Ph.D thesis synopsis at IIA.

A. Mangalam taught stellar astronomy a JAP course for the fall semester, 2002, guided a student from IISc, Physics department, Mr. T. N. Parashar under the visting student research programme for a project on cosmology in December 2002, prepared problem sets in Stellar Astronomy and Fluid Mechanics and assessed the students as part of extra course work assigned by the Board of Graduate Studies in January-April 2003. He is one of the coordinators of the Summer School program at IIA in 2003.

K.N. Nagendra continued to teach for the 2nd consecutive year, as 'Guest Faculty' at the Physics Dept., Bangalore University, Gnana Bharathi Campus, delivering 20 Lectures in Quantum Mechanics and Spectroscopy for Senior M.Sc Students. Nagendra serves as a co-guide to Ms. Yee Yee Oo, of Mandalay University, Myanmar, on a Govt. of India Fellowship under ICCR. He has guided an M.Sc. Student under the SPSP-Program (the Summer Project Students Program) organized by the BGS. (May 2002-July 2002).

T.P. Prabhu guided the short-term project on 'Study of atmospheric water vapour at Hanle' by Nishant Agarwal, St Stephens College, New Delhi, during the summer of 2002, at the CREST campus.

P.S. Parihar guided the short-term project on 'Photometric and spectroscopic studies of binary stars' by B.J. Medhi, Gauhati University, during August 2002, at the CREST campus.

K.E. Rangarajan taught 'Stellar Physics' at the IISc, JAP course in Aug-Dec, 2002 semester.

D.K. Sahu guided the short-term project on 'Analysis of Galaxy images and spectra' by Ravi Kiron, Birla Science Centre, Hyderabad, during October 2002, at the CREST campus.

S. Sengupta has guided a summer student Mr. Devdeep Sarkar from IIT Kanpur on the project entitled "Probing Our Universe with Cosmic Microwave Background Radiation". The project work is related with the theory and observation of Sunyaev-Zel'dovich Effect.

A. Subramaniam guided Saigeetha for her summer project in May-June 2002.The title of the project was "Photometry of star clusters". The project comprised of reducing the U,B,V,I CCD data of the cluster Collinder 74, estimating the stellar magnitudes using point spread function, converting the instrumental magnitudes to standard magnitudes with the help of standard stars. The final colour-magnitude diagrams, V vs (B–V), B vs (U–B), and V vs (V–I) were obtained.

Involvement with scientific community and in educational programmes

G.C. Anupama is a co-PI of the project "Symbiotic binary stars and related objects"approved under the Indo-Polish Exchange Programme. Served as a member of the national committee to review the project "Virtual Observatory - India" headed by A. Kembhavi and J. Narlikar (IUCAA) and funded by the Ministry of Information Technology, Govt. of India.

H.C. Bhatt serves as Editor, Bulletin of Astronomical Society of India; Served as a member GMRT Time Allocation Committee; Gave lectures at the The Jawaharlal Nehru Planetarium, Bangalore under the REAP Programme; Examined PhD theses for Kumaun University, Nainital.

B.P. Das was one of the Directors of the SERC school on "Precision spectroscopy of atoms, moleculeas and Bose condensates that was held in IISc, Bangalore in February and March 2003. He continues to be an Executive Committe Member of the Indian Physics Association and the Programme Advisory Committee of the Department of Science and Technology,Government of India

R.T. Gangadhara has been working on development of software for data simulation, pipeline, and reduction for ASTROSAT–UVIT. There are two scientists and three engineers to work on this project. Each one is actively working on different parts of the project.

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

A. Mangalam is a part of the REAP training and research program held by the Bangalore Association for Science Education (BASE), Nehru Planetarium for undergraduate students in Physics in which IIA is a participating institute.

K.N. Nagendra served as a member of the International Scientific organizing Committee (SOC) which organized the "3rd International Workshop on Solar Polarization", in Puerto de la Cruz, Tenerife, Spain, during Sept 30-Oct 4, 2002.

T.P. Prabhu is serving as a member of the Scientific Advisory Committee of IUCAA, Pune for the period 2001-03.

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

Public outreach and community activities

S.P. Bagare participated in a video conferencing workshop for science teachers, on invitation from the Department of Science Education Research and Training, Government of Karnataka, during January 2003. He gave introductory talks and interacted with teachers in the program which simultaneously covered all the districts of the state. Education outreach division of ISRO rendered the technical support for video conferencing.

S.P. Bagare gave a talk on 'The Solar System and Life on Earth' at the Shri Ramakrishna Mission School, Bangalore, in December 2002.

P. Bhattacharjee gave the following popular lectures : The Early Universe BASE, Nehru Planetarium, Bangalore, 8 June 2002. X-Ray and Neutrino Astronomy: 2002 Physics Nobel Prize Christ College, Bangalore, November 2002. The Early Universe Radio Talk given on Gyan Vani, Bangalore, Educational Channel of IGNOU, FM 106.7 MHz: Broadcast on 3 September 2002 at 9 PM.

R.T. Gangadhara gave a refresher course at Thunga Maha Vidyalaya, Thirthalli, during 22-23 December, 2002. He also gave a couple of invited lectures on (i) Life cycle of stars and (ii) Physical characteristics of stars.

R.C. Kapoor has been looking after visits of numerous students groups to the Koramangala and Hosakote campuses of the Institute. This year these have included visits by Jagadis Bose National Science Talent Search, Kolkata, Vishvachetana Saamskruthika Sangha (R), Bangalore and Government Arts College, Trivandrum etc.

The All India Radio, Bangalore broadcast an interview of R.C. Kapoor on the topic of 'The Planetary Conjunction - 2002' on the 5th May 2002 - who spoke about the finest grouping of the five naked eye planets in the sky in almost 20 years.

R.C. Kapoor brought out a beautiful 'Album-2003' which had three colour pictures of the astronomical objects taken through the 2.34 m Vainu Bappu Telescope and three others through the Himalayan Chandra Telescope. It was distributed to staff and many scientists and institutions all over. The Album received appreciation from all quarters.

C. Sivaram on Supernovae, neutron stars and black holes - lecture given at Physics Dept. Mahaveer Jain College, Bangalore in September 2002.

A. Subramaniam gave a talk titled "Introduction to Astronomy" at the Physics Department, Govt. Victoria College, Palakkad, Kerala, on 16th October 2002. She organised visits to IIA for the graduate students of Govt. Victoria College, Palakkad and Govt. College, Thiruvananthapuram in October 2002.

Jagdev Singh is on the panel of experts for selection committees/Ph.D. examiners of Punjabi University, Patiala, Punjab. Jagdev Singh is member of the Board of studies in M.Sc. Physics (specialization with Astrophysics) for Mother Teresa Women's University, Kodaikanal, Tamil Nadu.

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

P. Bhattacharjee served as a member of the panel on Gravitation and Astroparticle Physics set up by the Indian Academy of Sciences for preparing the *Decadal Vision Document* for Astronomy & Astrophysics to be submitted to the Govt. of India. Currently serving in the referees' panel for the journals *Physical Review Letters*, *Physical Review D*, and *Pramana*, and has refereed a number of papers for these as well as other journals.

S. Giridhar continues to serve as organizing committee member of IAU Commission 45 and has made a proposal for a one-day discussion meeting to be held during GA 25 to be conducted at Sydney, Australia in July 2003. S. Giridhar also continues to serve as a Principal Investigator for a DST sponsored Indo-Mexican collaborative program and preparations are being made for the forthcoming visit by Mexican collaborator Prof. A. A. Ferro.

K.N. Nagendra has been a referee for the UGC funded Research Project submitted by a University Faculty Member.

B. Raghavendra Prasad gave lectures on Non-linear Optics to Students of Sri Sathya Sai Institute of Higher Learning, Whitefield Campus, during August 2002. He was member, DST (TSG) Expert Group on "Molecular Electronics, conducting polymers, Non-invasive and other bio-sensors". As a member of this committee, he evaluated various project proposals submitted to DST in the above-mentioned field during 10-11 February 2003 at National Physical Laboratory, New Delhi.

A.K.Saxena is a member of PARC committee for the project "Development of Device for Real Time Imaging through Turbulent Atmosphere." of IRDE, Dehra Dun. A.K.Saxena is the Chairman of the Project Review Committee for the project "Development of a phase sensor for Adaptive Optics

Applications" funded by IRDE, Dehra Dun. He continues to serve as an expert member of many national scientific project committees of ISRO, IRDE and BARC.

CREST : The National Geographic Channel included Indian Astronomical Observatory, Hanle, in its programme, 'Hot Science from India'. The videography was carried out at the remote control station, CREST campus. Door Darshan commissioned a full episode of 'Turning Point' programme on Indian Astronomical Observatory, Hanle. The videography at CREST was undertaken during the current year and that at Hanle planned for the early part of the next year.

50 students visited the CREST campus on 1 May 2002 for star watching and astronomy programme organized by the Vishvachetana Sanskritika Sangha, Bangalore. 17 students of M.P. Birla Institute for Fundamental Research, Bangalore, visited CREST on 22 October 2002 as a part of 100 hour certificate course in astronomy. 28 students of Govt. Arts College, Thiruvananthapuram, visited CREST on 25 October 2002 as a part of study tour. 18 students of Govt. Arts College, Palakkad, visited CREST on 31 October 2002 as a part of study tour. 40 students of Maharaja Sivajirao University, Baroda, visited CREST on 26 February 2003, as a part of study tour.

Popular articles

S. Chatterjee, Einstein too failed in exams (Hindustan Times, Lucknow edition, 12.07.02, 13.07.02). Xerox machines eclipsed inventor (Hindustan Times, Lucknow edition, 26.07.02). Remembering the Hiroshima catastrophe (Hindustan Times, Lucknow edition, 10.08.02). The man who got the Principia published (Hindustan Times, Lucknow edition, 22.02.2003). Aji hatey shatabarsha phire: prashanga bijnan (Natun chithi, 2002).

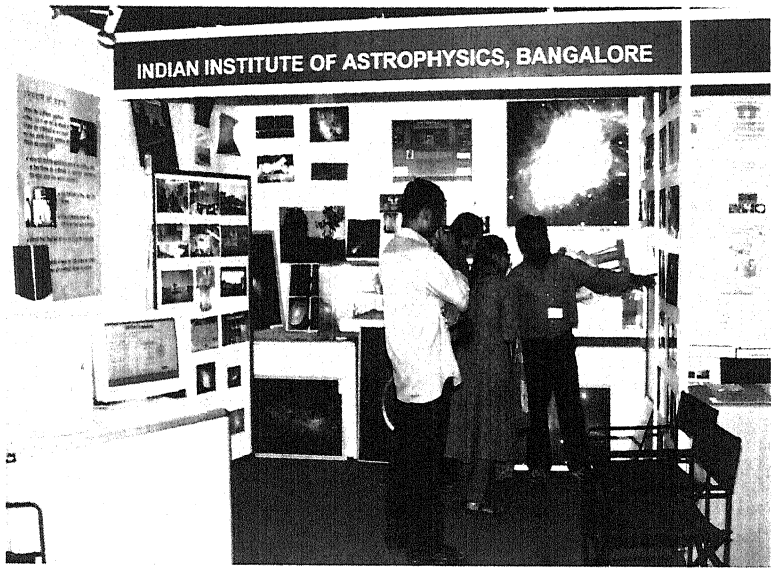
S & T Exhibition during the 90th Indian Science Congress, Bangalore University, Jnanabharathi Campus, Bangalore

R.C. Kapoor organized the Institute's participation in the Science & Technology Exhibition during the 90th Indian Science Congress that was held through 3-7 January 2003 in the Jnanabharathi Campus of the Bangalore University.

National Science Day 28th February 2003

Nearly 100 students from various schools in the vicinity had participated in the National Science Day programme held at IIA for the year 2003.

Observations of sunspots : The 7.5 cm telescope manufactured by the Central Scientific and Instruments Organisation (CSIO) was used to observe the sunspots. The telescope has been modified to project the sun's image on a white screen using a suitable projection lens set.



IIA stall at the S & T Exhibition during the 90th Indian Science Congress.

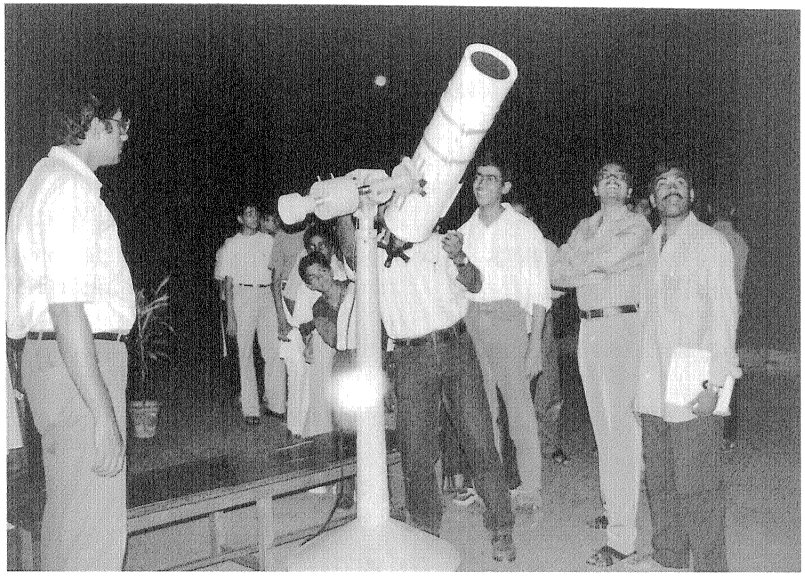
Three sunspots were visible on the disc of the sun on this occasion. Some details about the sun, the formation of sunspots and the telescope were explained to the students.

Star watch : The 15 cm Carl Zeiss telescope was used to observe some stars and planets, primarily, Jupiter and Satum. There was a very enthusiastic response from about 60 students and a few teachers from the schools that had participated in the morning program.

The students visited the Photonics Lab and saw the grinding and the polishing techniques. They learned the principles of optics.

The Himalayan Chandra Telescope documentary movie was screened. It gave an elaborate view about the Indian Astronomical Observatory, the highest in the world.

(R.C. Kapoor and P.K. Mahesh)



National Science Day, 28-2-2003 Sky Watch

Colloquia and talks given by visitors

Astronomy and Astrophysics division ,
Ashok Singal
Physical Research Laboratory , Navarangapura, Ahmedabad.
2 April 2002

Source Regions of Solar Coronal Mass Ejections
Prasad Subramanian
Solar Noise Storms Observed with the GMRT.
IUCAA, Pune.
4 April 2002

Experiments on Crystallised Ions in a Paul Trap
Alexanderos Drakondis
Institute of Physics, University of Germany
3 May 2002

The GMOS Multi-object spectrograph at the Gemini Observatory
Dr Rick Murowinski
DAO, CANADA
30 May 2002

Central structural parameters of early type Galaxies- Relics of the Formation process,
Swara Ravindranath
Carnegie Observatories, Pasadena .
11 June 2002

Cosmology with D- Branes. (Seminar)
Urjit Yajnik
IIT, Mumbai
21 June 2002

Searching for ^{6}Li in stars with planets.
David Lambert
University of Texas, Austin, Texas,USA
20 August 2002

Relativistic atomic structure studies of mercury atom.
Angom Dilip
Physical Research Laboratory, Ahmedabad
21 August 2002

Double -photoionization of atoms.
C.Sur
Department of Physics, Visva- Bharti,Santiniketan
29 August 2002

X-Ray probes of cosmic star formation history
Pranab Ghosh
Tata Institute of Fundamental Research, Mumbai
24 September 2002

Do GRBs emit TeV Gamma Rays
Nayantara Gupta
Indian Association for Cultivation of Science, Kolkata
27 September 2002

Gamma Ray Astronomy
P.R.Vishwanath
16 October 2002

Magic and Magic II
Masahiro Teshima
Institute for Cosmic Ray Research, University of Tokyo. Japan
24 December 2002

Bipolar flows in Seyfert galaxies
Mark Whittle
Dept. of Astronomy, University of Virginia, USA
31 December 2002

When the Universe was young
Mark Whittle
University of Virginia, USA
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Rajesh Nayak
IUCAA, Pune
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The Dynamical Transition Region: As seen from SOHO
Dipankar Banerjee
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Joanna Mikolajewska
N.Copernicus Astronomical Centre
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Is the solar chromosphere heated by giant killer waves?
W.Kalkofen
Harvard- Smithsonian Center for Astrophysics, Cambridge, USA
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Mixing in stellar radiation zones
Jean-Paul Zahn
Observatoire de Paris- Meudon, France
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Suzy Collin
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Extended radio emission in merging clusters of galaxies
Tiziana Venturi
Istituto di Radioastronomia, CNR
Bologna, Italy
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Solar physics from space in the last and next decades
Takeo Kosugi
Institute of Space and Astronomical Science
(ISAS), Japan
27 February 2003

Nonlinear processes associated with interplanetary radio bursts
G.Thejappa
NASA/Goddard Space Flight Center , Greenbelt, MD, USA
11 March 2003

APPENDIX C

Vainu Bappu Observatory

Time Allocation during 2002-2003

I. VBT		Total No. of Proposals received	58
	a.	No. of Spectroscopic Proposals	32
	b.	No. of Photometric Proposals	26
	c.	Total No. of Nights requested	478
	d.	No. of Nights requested for Spectroscopic work	294
	e.	No. of Nights requested for Photometric Work	184

*Telescope not available for regular observations from June 2002.

II. 102-cm		Total No. of Proposals received	5
	a.	No. of Spectroscopic Proposals	2
	b.	No. of Photometric Proposals	3
	c.	Total No. of Nights requested	52
	d.	No. of Nights requested for Spectroscopic work	13
	e.	No. of Nights requested for Photometric Work	39

Sky conditions at Vainu Bappu Observatory

Year	Month	Spectroscopic Hours	Photometric Hours
2002	April	236	40
	May	86	7
	June	33	6
	July	49	2
	August	45	–
	September	41	2
	October	94	21
	November	95	20
	December	167	37
2003	January	227	39
	February	168	24
	March	170	38
	Total	1411	236

Sky conditions at IAO, Hanle

Year	Month	Photometric (night hrs)	Spectroscopic (night hrs)	Total (night hrs)
2002	April	78	117	240
	May	88	108	217
	June	79	102	210
	July	121	163	217
	August	45	56	248
	September	118	168	270
	October	179	225	310
	November	251	292	330
	December	141	180	341
2003	January	193	215	341
	February	114	127	280
	March	118	158	279
	Total	1525	1911	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
2002	April	19	17	9	26	1	3	17	5	–
	May	22	21	–	24	1	4	11	7	1
	June	13	13	–	20	–	2	11	7	–
	July	9	10	–	12	–	–	9	3	–
	August	9	9	–	10	–	–	8	2	–
	September	20	21	–	25	–	4	16	5	–
	October	2	9	–	13	–	2	7	4	–
	November	13	13	–	15	–	2	8	4	1
	December	17	20	–	22	–	5	11	6	–
2003	January	20	19	–	24	3	2	16	3	–
	February	22	23	–	25	2	11	10	2	–
	March	27	28	–	30	2	4	20	2	2
	Total	193	203	9	246	9	39	144	50	4

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
2002	April	12	1	6	3	–	2
	May	17	2	12	1	1	–
	June	4	–	3	–	1	–
	July	3	–	2	–	1	–
	August	5	–	4	–	–	–
	September	5	–	5	–	–	–
	October	7	–	7	–	–	–
	November	11	–	9	–	2	–
	December	6	–	3	–	2	1
2003	January	21	–	17	–	4	–
	February	19	2	13	–	1	2
	March	16	1	12	–	3	–
	Total	126	6	93	4	15	5