INDIAN INSTITUTE OF ASTROPHYSICS

Annual Report for the year ending March 31, 1977

HIGHLIGHT OF THE YEAR

Principal highlight of the year has been the discovery of a ring system of satellites around the planet Uranus. This most unexpected discovery made by scientists of the Institute is undoubtedly one of the major discoveries made of the solar system, during the twentieth century.

SOLAR PHYSICS

Sivaraman and Venkatachalam continued their study of the dynamical behaviour of the bright points in Ca II H-line spectra. About 1500 profiles covering a sequence of spectra over 30 minutes of time were traced from the original film. These data are being processed to obtain the subtracted profiles from which the travelling disturbances can be identified and a calculation made of their dynamical parameters.

Venkitachalam and Jagdev Singh have continued to obtain integrated K line spectra of the Sun with the Solar tower telescope. Singh obtained on a number of occasions simultaneous spectroheliograms and spectrograms in the K line with the 34 cm solar image. Many spectroheliograms have been obtained in the D_1 line over active regions for a study of the D_3 line characteristics.

Jagdev Singh has extended his measurements of the areas of the calcium network to detect a possible dependence on solar cycle of Ca II network areas. Those refering to the minimum phase of 1964 and the maximum phases of 1928, 1947 and 1958 have been measured. The new measures confirm the trend in the most probable sizes reported on last year; the super-granular cells have mean sizes of 22600 km in the years of minimum solar activity and 21750 km for the years 1917 and 1928 (sunspot maximum) and 20820 km for the years 1947 and 1958, which represent the years of very high solar activity.

Srivastava has commenced a study of the K line widths in prominences. He has obtained prominence spectra in the VI order of the K line with simultaneous spectroheliograms to enable evaluation of slit location on the prominence image.

Gokhale in collaboration with S. M. Chitre of the Tata Institute of Fundamental Research has investigated the instabilities in a polytropic model of the sunspot penumbra. The results revealed the following three instabilities with a uniform horizontal magnetic field :

(i) a convective instability with length-scales and time-scales comparable to those of the penumbral filaments, (ii) a "slow-mode" overstability

having properties in fair agreement with the observed properties of the velocity oscillations and the penumbral waves, and (iii) a slowly growing "fast-mode" overstability (which may not be observable). As the field is reduced, the second and the third of the above three modes tend to become identical with the normal-granulation mode and the five-minute-oscillation mode respectively in the normal photosphere.

The investigation of the filamentary model of the solar magnetic field was continued by Gokhale. A stronger argument is found for the earlier contention that the "fundamental flux tubes" in that model provide the most efficient transport of the energy extracted by them from the convective flows in large ($> 10^5$km) depths. If the convection near the base of the solar convection zone consists of about 10 convective cells, each extending over $\sim \pi/5$ radians in longitude and starting with a velocity amplitude of $\sim 10^4$ cm s^{-1}, such a pattern of convection will last for a period $\sim$ 11 y, at the end of which it will be replaced by a similar new pattern. The generation of each new pattern will be through azimuthal perturbations of the rotation of the convection zone, and will involve high velocity-gradients near certain meridian planes. These high velocity gradients will generate pairs of current sheets and the associated magnetic flux sheaths might split into "clusters" of thousands of "fundamental flux tubes". On the basis of these possibilities, a model is proposed for the periodic reversal of the Sun's general magnetic field with a period $\sim$ 11 y. Such a model would be free from the difficulties which are present in the earlier models.

Assuming multilevel atom model, Raju has computed absolute ultraviolet line intensities for the ions Ne IV, Mg VI, Al VII, Si VIII, P IX and S X. These ions belong to the nitrogen isoelectronic sequence. The ions considered are representative of the chromosphere-corona transition region and the corona. To compute absolute line intensities a spherically symmetric model atmosphere constructed by Elzner has been adopted. In setting up the model atmosphere, Elzner has taken the following aspects into consideration: for the run of temperature, the corona is assumed to be nearly at constant temperature followed by a region where the temperature gradient is proportional to $T^{-5/2}$. Below 10^5k, the temperature gradient is very steep and is approximated by a constant value in two regions upto 10^4k. For the run of electron density the transition region was assumed to be in hydrostatic equilibrium. This was considered to be a better approximation than the often adopted constant pressure. In the corona, above 50000 km, Baumbach formulae were used and in the intervening region values were interpolated.

Some of the lines belonging to the ions considered have observable intensities, but observational data is lacking. Computed intensities for such lines may prove useful in resolving the difficulties associated with line identification, masking or blending due to lines arising from ions belonging to other isoelectronic sequences. For the lines with appreciable intensities the variation of emissivity with height in the atmosphere has also been studied. This analysis enables one to know the relative contribution made by different layers of the transition region and the corona to total line intensities. These lines lie in the ultra-violet region of the spectrum. In addition to the computation of line intensities, Raju has studied the variation of line intensity ratios with electron density and temperature as parameters. This provides us with an useful diagnostic tool in determining these two important plasma parameters. In particular, one would know whether a line is observable in the quiet region or active region of the solar atmosphere.

STELLAR PHYSICS

Both Coude and Cassegrain spectrographs have been in use in a search for HeI 5876 absorption of chromospheric origin in stars with appreciable H and K emission. The dispersions employed are 4, 17 and 20Å/mm depending on the star's brightness. Spectra have been obtained of many G and K giants at 12Å/mm for a study of changes in the line profiles and intensities of the K emission. Canopus spectra have been obtained at 2.8 Å/mm for a study of the possible time variation of emission core intensity. These are compared to similar contours derived of the 1965 spectrum obtained by Warner and generously made available by Dr. Feast.

Scaria has continued his programme of direct photography of globular clusters in the blue, visual and near infrared wavelengths. The detailed isodensitometry of the brighter clusters has progressed well. Measures of ellipticity are complete.

Mallik has continued his theoretical studies on the birthrate and number of planetary nebulae. On the basis of the galactic evolution model due to Talbot and Arnett and an initial mass function determined from the currently observed luminosity function, he has derived a birthrate of 6 planetaries $kpc^{-3}yr^{-1}$ in the solar neighbourhood. This implies a total of 60,000 planetaries in the Galaxy, if the distribution were assumed uniform. Mass models of the Galaxy show a pronounced central concentration in mass while the observations reveal a large increase in the number of stars of later spectral types towards the nucleus. It is quite likely,

therefore, that planetaries are very much more abundant in the inner regions of the Galaxy. Innanen's model of the Galaxy is used in conjunction with a parametrised birthrate function to determine the surface density of planetaries as a function of the distance from the galactic nucleus. With the recently determined distribution of planetary nebula masses in the solar neighbourhood coupled with the birthrate, the total rate of mass return to the interstellar medium through the planetary nebula phenomenon can be evaluated. The present work indicates a value of $3.45 \times 10^{-4} M_{\odot}$ $kpc^{-3}\,yr^{-1}$ in the solar neighbourhood. Once this quantity is obtained for different radial distances in the plane it is possible to find out the enrichment of the interstellar medium through the planetary nebula phenomenon. Because of the large rate of mass return it is believed that the enrichment of N and O observed across the discs of spiral galaxies might have been caused by the above phenomenon. Mallik is currently engaged in evaluating quantitative limits on such enrichment. The reason for the absence of planetaries in the halo of the Galaxy is also being investigated.

Spectrograms of 28 Tau have been obtained in the red and blue regions of the spectrum of the current shell outburst. The star Kappa Canis Majoris does not show any more He I 5875 in emission. Apart from obtaining coude spectra in the red and blue spectral regions of this star, scans for a study of the continuum energy distribution have also been made.

Prabhu has continued to obtain spectra at low dispersion of Nova V1500 Cygni. These were obtained with an objective grating during the months of June, September and October. The intensities of the forbidden lines of doubly ionized oxygen were on the increase and were most prominent in October. Other lines seen on the spectra were besides the Balmer lines, those due to [N II] and [Ne V]. Nova NQ Vulpecula was observed soon after discovery. The spectra obtained show P Cygni characteristics, and the H-alpha line had a complex structure.

Lunar occultation observations continue to be made with the fast recording photometer on the 102-cm reflector. Twenty one occultations have been observed, of which four events pertain to stars brighter than the sixth magnitude. Much progress has been made on the reduction of the Spica record of last year.

Equivalent widths of the neutral oxygen line 7774Å and a neighbouring iron line 7748Å have been used by Kameswara Rao and Sushma Mallik to establish a luminosity calibration for B2-F5 supergiants. Since, in the spectral range F5-G2, the strength of the OI line is not only sensitive to the absolute magnitude but also to temperature, the product of the

equivalent widths of the two O I and Fe I lines becomes sensitive only to the absolute visual magnitude. The calibration is established for fifteen supergiants with known M_v either from membership in clusters or from other spectroscopic criteria. The calibration has been applied to the hydrogen deficient carbon-rich supergiants R CrB and XX Cam after making correction for the differences in the continuous opacity with respect to normal supergiants.

Kameswara Rao has also continued his programme of obtaining band strengths of CH and NH-poor G and K giants with the automated scanner.

A study by Rajamohan of the observed rotational velocities of normal main sequence members of clusters and associations, earlier than Fo, indicate that they are consistent with the hypothesis that the dispersion is small in the true rotational velocities of stars of a given mass as they arrive on the main sequence. The mean true rotational velocities closely follow the highest observed rotational velocities of field stars.

Rajamohan and Babu find the intrinsic rotational velocities of magnetic variables with periods greater than a day, to be related to their colour index or equivalently to their masses. It is also found that the components of spectroscopic binaries rotate slower than the single stars of similar colours. The present work favours the associated periods of 4.23 days and 2.675 days for HD 140728 and HD 140160 respectively. Thirtyfour kilogauss star, HD 215441, is most likely a spectroscopic binary seen pole-on.

INTERSTELLAR MEDIUM

Theoretical results on colours and polarization of light from a reflection nebula in the form of a homogeneous plane-parallel slab model with the star in the rear, have been considered by Shah from the viewpoint of dielectric versus metallic single spherical grains. Silicate and graphite, respectively are chosen as representative materials. Contrary to some earlier work in the literature, Shah finds that silicate grains can also play a role in the phenomena of reflection nebulae. A distribution of sizes with parameter $a_o = 0.4\mu m$ for silicate spheres gives $(B-V)_{*-N}$ and $(V-B)_{*-N}$ colours close to observations. Similarly, for graphite, the size parameter $a_o = 0.3\mu m$ is favourable. Therefore, one cannot exclude the silicate and graphite grains at least as a small admixture or in the form of composite grains. For size parameters $a_o = 0.1\mu m$, the expected polarization is positive for all offset angles. Furthermore, silicate grains with $a_o = 0.2\mu m$, give polarization very nearly matching the observations upto offset angle $\phi \simeq 10$ min. of arc. Graphite grains give far too high a

polarization and so they cannot be exclusively selected, except in the cases of composite and mixtures of grains.

Shah has further considered core-mantle spherical grains and mixture of spherical grains within a homogenous plane-parallel slab model of a reflection nebula with the star in the rear. Wavelength dependent indices of refraction have been used throughout for all materials.

For composite grains with core radius (r_1) 0.04μm and 0.08μm and mantle to core volume ratio (V_m/V_c) 0.04 to 0.88, graphite, silicate and silicon carbide cores give much larger positive colours from offset angle ϕ = 0 to 20 min. of arc as compared to the observations. The mantle consists of ice in all cases. The negative values of $(B-V)_{*-N}$ colour at higher ϕ demanded by observations show up mostly in the case of graphite and SiC cores with $r_1 = 0.12\mu$m. The composite grains having graphite core and ice mantle with $r_1 = 0.12\mu$m and $V_m/V_c \geq 0.3$ produce $(B-V)_{*-N}$ colour differences which are somewhat close to the observations. This also holds for $(U-B)_{*-N}$. However, proper gradient and range of colours are not available. For $r_1 = 0.04\mu$m and $V_m/V_c = 0.044$, the polarization is nearly the same for graphite and silicate cores. Their deviations from SiC cores increase as one goes from V to U band. As r_1 increases to 0.12 μm, the graphite and silicate cores still produce almost the same degree of polarization in V and B bands. The difference between the graphite and silicate cores shows up prominently in the case of U band especially when $V_m/V_c > 0.044$. Unfortunately, there are no data on nebular polarization in the U band. Contrary to the observations, SiC cores with $r_1 = 0.12\mu$m produce negative polarization in the B band.

Mixtures of grains composed of ice, graphite, silicate and silicon carbide have been considered two or three at a time in various proportions. The 'exp (a^3)' type of size distribution function is adopted for each species of the grains.

HIGH ENERGY ASTROPHYSICS

Kochhar has presented a classification scheme for pulsars by which distinction is made between three types of pulsars, termed L, S and D. Type S pulsars are formed as a result of supernova explosions of single stars. Types D and L pertain to pulsars which come from massive close binary systems. Pulsars formed by supernova explosions in binaries, that lead to their disruption, belong to type D while the old, rejuvenated neutron stars liberated from the binaries by the supernova explosion of the comparison stars constitute type L. Type D consists of two subsets; a pulsar belongs to type D_1 if its formation, accompanied by the disruption

of the binary, is a result of the first supernova explosion; to type D_1, if a result of the second. It has been proposed that single runaway stars are formed by the carbon-detonation supernova explosion of the companion star, which does not leave behind any compact core.

An observable manifestation of this classification scheme is the angle between the pulsar space velocity vector and the spin axis. If the neutron star is accelerated along its spin axis at the time of its formation, the value of this angle should be close to 0^{o} for type S pulsars, near 90^{o} for type L pulsars and have intermediate values for those that belong to type D.

This classification scheme has two significant implications. First, type D_2 and L pulsars are formed about 200 pc above or below the galactic plane. Secondly, type L pulsars are spun up during and after the x-ray stage of the binary so that although they are about $5x10^6$ years old as neutron stars, they appear as young pulsars.

In collaboration with J.V. Narlikar of the Tata Institute of Fundamental Research, Kapoor has examined the problem of photon emission from a white hole in non-radial directions, especially when the surface of the exploding object is still within its Schwarzschild radius. The analysis uses standard general relativistic formalism which suggests that photons can leak out of the Schwarzschild radius and may suffer a blue shift, although lesser in extent compared to that for the radial case. The non-radial photons attribute a finite, time varying, angular size to the exploding object. The upper limit on the impact parameter of the non-radial photons has been calculated under the requirement that such rays are blue shifted. For the appearance of rings around white holes a critical value that is considerably larger than values of impact parameter for blue shifted rays, is needed. Hence the amount of gravitational bending would not be very large. Further the white hole expands so fast that it soon occupies the radii at which the rings could occur and would not allow even the rays emitted at the critical values of the impact parameter to go round the object for ever. The apparent angular size of the white hole determined by blue shifted rays, grows so rapidly in the early stages of its expansion, that it produces the appearance of a "superluminal" expansion.

Kapoor has studied the problem of the gravitational recoil of a gignatic black hole ($M \sim 10^{8.9} M\odot$) formed in the non-spherical gravitational collapse of the nuclear part of a typical galaxy as a consequence of the anisotropic emission of gravitational radiation. Accretion of gaseous matter and stellar captures while on its way out can lead to the formation of an accretion disk-star system about the hole. Consequently the hole can be luminous enough to be observable after it emerges out of the galaxy

the phenomenon may be important in relation to the observations of quasar-galaxy associations in a number of cases.

PHYSICS OF THE SOLAR SYSTEM

Bhattacharyya and Kuppuswamy have observed the occultation of the star SAO 158687 by the planet Uranus on March 10, 1977. The light curve was the basis of the discovery at the Institute of a swarm of satellites around the planet. Preliminary inferences of the light variation indicate the validity of the postulate that an extended Saturn-like ring system exists around the planet.

The analysis of the high resolution drift scans across the cometary coma of Comet West, obtained on March 24, 1976, when the heliocentric distance of the comet was 0.855 a.u. has been completed. The drift scans consist of scans in the C_2 (0,0), CN (0,0) bands and in the continuum at 5000Å. The analysis has yielded the total number of molecules of the two species, their scale lengths and lifetimes. The results also give an accurate measure of the dimensions of the coma in the light of C_2 and CN bands.

The analysis of the spectral scans of the Comet both across the coma and the tail, obtained from March 6, through March 23, is in progress.

RADIO ASTRONOMY

The decameter wave antenna system, which was in the final phase of construction last year, is now complete. Thd present dimensions of the East-West and the North-South arms are 1.5 km and 0.5 km respectively. In order to electrically steer the antenna response in the NS direction, about 100 amplifiers and phase shifters have been made and installed along the NS arm. The beam is steerable within $\pm$ 45° of the zenith in the NS direction. The half power beamwidths in the EW and NS directions are 32 arc minutes and 50 arc minutes respectively, at the zenith, and for uniform illumination of the array. The total effective area is approximately 30000 square metres.

A correlation receiving system has been designed, constructed and installed at Gauribidanur. At the moment the output of the receiver is in the form of analog chart records, which will be manually digitised for computer processing. Work is in progress on the construction of a system to digitise the outputs of the final DC amplifiers and record them on paper tapes.

During the last few months, several tests have been made to check the performance of the antenna, specially with regard to shape of the beam and the relative sidelobe level. Electronic systems for gain and phase calibration of the array have also been developed and built.

SOLAR-TERRESTRIAL RELATIONSHIPS

Sastri and Murthy have studied the seasonal variation in the occurrence of night time Pi2 micropulsations at Kodaikanal using normal run magnetogram data (Watson Variometer) covering the period July 1972-June 1975. The occurrence of night time Pi2 micropulsations is seen to exhibit a semiannual variation with maxima in local winter and summer and minima at the equinoxes. This result indicates a latitudinal dependence of the seasonal variation in night time Pi2 occurrence and stresses the need for a detailed study of this aspect with the aid of simultaneous data obtained at stations that are spread over a wide range of latitudes but which are at the same longitude.

B. S. Murthy in collaboration with Prof. Rastogi and M. R. Deshpande finds that the radio beacon signals received at Ootacamund (11.45°N, 76.70°E dip 4°N) on 40MH_z, 140MH_z and 360MH_z from the ATS-6 satellite at 34°E longitude exhibit on some occasions intense scintillations during the day time. These daytime scintillation events are not associated with the 'q' type of sporadic E layer as seen at Kodaikanal (10.23°N, 77.49°E dip 3.5°N) but are due to the ionization patches in the E region indicated by the occurrence on the ionograms of either high or flat type of sporadic E layer.

Faraday fading of 40.01 MH_z transmissions from the orbiting satellite 'INTASAT' has been recorded for nearly two years : Nov. 1974-Sept 1976. The beacon transmissions from INTASAT ceased from 6 October 1976. The data are now being analysed to study several aspects of the equatorial ionosphere : latitudinal variation of total electron content, large scale ionization irregularities and scintillations.

Routine schedules of vertical ionospheric sounding of and recording of geomagnetic elements continued during the period of this report. The scaled data have been sent in standard format to World Data Centres and to various organizations in india.

INSTRUMENTATION

Saxena has used Jones calculus for presenting a theory of fringes of the Babinet compensator. The performance of the system, that is governed

by the compansator-polaroid unit, has been evaluated in terms of fringe visibility. Criteria have been evolved for the proper choice of the compensator-polaroid pair that optimises measurement accuracy.

Singh has proposed three new types of concave grating monochromators that fulfill requirements of such an instrument in the vacuum ultraviolet region. The monochromators are compact and are simple to operate. Using the theory of Beutler-Namioka as well as by ray-tracing procedures, aberrations of the proposed systems are found to be minimal.

The year has seen much progress on the 1300 mm optical grinding and polishing machine. The machine is expected to be installed at Bangalore before the end of December 1977. The optics laboratory has continued work on the figuring of the 76-cm paraboloid and its Wynne 3-element prime focus corrector. Work on a new 43-60-cm Schmidt system operating at f 3 has started. The primary mirror has been completed during the year. The complete system will be used in the mounting fabricated earlier for the Planetary programme. Other optical systems fabricated include an off-axis Schmidt of 15-cm aperture for use in an image tube spectrograph and paraboloids and achromats in the 20-30-cm range. The laboratory has furnished technical help to the Defence Research Laboratories at Hyderabad and Bangalore, the Vikram Sarabhai Space Centre, the Indian Space Research Organization and Bharat Electronics of Bangalore.

The electronics laboratory has continued to provide much of the back-up facility for new instrumentation and the improvement of existing facilities. These include the direct digitization and display of data, a photoeletric exposure meter for the coude spectrograph with an up-down counter system, and several other accessories related to pulse counting techniques. The drive and co-ordinate display system of the 75-cm telescope have also been completed.

OBSERVING CONDITIONS AT KAVALUR

There were 1492 hours of observing at Kavalur. Photometry could have been done on 697 hours or 47 percent of the time. On 107 nights, spectroscopic work was carried out for a duration of 9 hours or greater. An average seeing better than 1.5 seconds of arc was available on 88 nights. The table below shows the month-wise distribution of these features.

Month	Hours of Spectro-scopic work	Hours of possible photometry	Number of nights when spectro-scopic work 9Hrs or greater was done	Number of nights with average seeing better than 1.5''
1976 Apr	171	94	17	3
May	136.5	60.5	8	3
Jun	82	25	6	5
Jul	11	0	0	2
Aug	24	0	0	3
Sep	81	18	2	6
Oct	103.5	58.5	7	8
Nov	56	15	1	11
Dec	140.5	65	9	11
1977 Jan	287.5	137.5	26	18
Feb	185	98	12	10
Mar	214	125	19	8
TOTAL	1492.0	696.5	107	88

THE 234 CM TELESCOPE

A complete concept report for the telescope has been prepared by the consultants M/s. Tata-Dilworth, Secord, Meagher & Associates (TDSMA). This has been accepted by the Council. The design engineering of various systems of the telescope has progressed well. TDSMA have also been commissioned to design the Mirror grinding machine for the 236 cm Zerodur blank.

The site of the telescope was selected to be at Kavalur. The Tamilnadu Government have agreed to lease an additional sixty acres of forest land to the Institute for his purpose. Meanwhile the construction of the dome and tower has been entrusted to the engineering wing of the Department of Space, and work on the foundations commenced before the end of the year.

Action for acquisition of the Diesel Generating sets for standby power, Dome Crane, Cassegrain hydraulic platform have been taken.

LIBRARY

235 books were added to the library during the year. The Institute subscribed to 120 journals. We continue to receive publications from other observatories and research institutions on an exchange basis.

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14.	P. S. Murthy	Electronic transitions of aluminium monoxide. Chemical Physics. (in press)
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17.	P. S. Murthy	On AlF lines in sun spots. Solar Physics (in press)
18.	T. P. Prabhu	The spectrum of Nova Sagittarii, 1977. Bull. Astr. Soc. India (in press)
19.	N. K. Rao S. G. V. Mallik	Equivalent width of OI λ 7774 and absolute magnitude relation for F and G supergiants. MNRAS (in press)
20.	R. G. Rastogi M. R. Deshpande B. S. Murthy	Daytime satellite scintillation and sporadic E near the magnetic equator. Geophys. Lett. (in press)
21.	J. H. Sastri B. S. Murthy	On the occurrence of AQDs at Kodaikanal. J. Geomagn. Geoelect. (in press)
22.	J. H. Sastri B. S. Murthy	Seasonal variation of night Pi 2 micropulse at Kodaikanal. J. Met. Hydr. Geophysics (in press)
23.	G. A. Shah	Optical colours and polarization of a model reflection Nebula II. Silicate and Graphite grains in Nebula with the star in the rear. Astron. Nach. **298**, 316-325.

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25.	M. Singh	Theory of Holographic plane gratings. Indian J. Pure Appl. Phys. **15**, 338-344.
26.	M. Singh	A new monochromatiors of concave grating suitable for space telescope. Applied Optics (in press)
27.	P. Venkatakrishnan and M. H. Gokhale	Transmission of acoustic energy across a magnetic fluxs heath Solar Physics. (in press)

STAFF

Academic Staff in position during the year were as follows :

1. M. K. V. Bappu, Ph.D. — Director
2. J. C. Bhattacharyya, D.Phil. — Associate Professor
3. M. H. Gokhale, Ph.D. — Reader
4. A. P. Jayarajan, M.A. — Reader
5. P. K. Raju, Ph.D. — Reader
6. Ch. V. Sastry, Ph.D. — Reader
7. G. A. Shah, Ph.D. — Reader
8. K. R. Sivaraman, Ph.D. — Reader
9. R. K. Kochhar, Ph.D. — Fellow
10. D. C. V. Mallik, Ph.D. — Fellow
11. N. Kameswara Rao, Ph D. — Fellow
12. J. Hanumath Sastri, Ph.D. — Fellow
13. Mahipal Singh, D.Phil. — Fellow
14. R. C. Kapoor, M.Sc. — Research Associate
15. B. S. Murthy, Ph.D. — Research Associate
16. M. Parthasarathy, M.Sc. — Research Associate
17. T. P. Prabhu, M.Sc. — Research Associate
18. K. C. A. Raheem, B.Sc. — Research Associate
19. R. Rajamohan, Ph. D. — Research Associate
20. A. K. Saxena, M.Sc. — Research Associate
21. K. K. Scaria, M.Sc. — Research Associate
22. Jagdev Singh, M.Sc. — Research Associate

23. P. Venkatakrishnan, M.Sc. — Research Associate
24. P. P. Venkitachalam, M.Sc. — Research Associate
25. N. K. Srivastava, Ph.D. — Post-doctoral Fellow
26. G. S. D. Babu, M.Sc. — Visiting Research Associate.

The Technical, Administrative and Non-Technical Maintenance staff numbered 113.

COUNCIL MEETINGS

The Governing Council of the Institute met twice and the Finance Committee once during the year at New Delhi

BUILDINGS AND GROUNDS

There is much progress to report on the construction by the CPWD of the main laboratory at Bangalore. The optics laboratory has moved into its new building in the campus. As in previous years the fire lines at Kodaikanal and Kavalur were kept in good condition. Work has commenced at Kavalur on the construction of a new dome and tower for the 75 cm reflector as well as some accommodation for visiting observers to Kavalur.

SCIENTIFIC MEETINGS

Dr. M. K. V. Bappu attended the 16th General Assembly of the IAU in August 1976 and IAU Colloquium 36 at Nice on the Energy Balance and Hydrodynamics of the Solar Chromosphere and Corona. At the Grenoble meeting, Dr. Bappu was Chairman of the Resolutions Committee and was also elected President of Commission 12 on the Solar Atmosphere for the term 1976-79. Meetings in India attended by Dr. Bappu include the Infrared Astronomy Workshop at Ahmedabad, the annual meeting of the Astronomical Society of India held at Naini Tal and the Indian Science Congress at Bhubaneswar where he was President of the Physics section. Dr. Bappu also continued as Chairman of the Indian National Committee of Astronomy.

Dr. J. C. Bhattacharyya attended the symposium on the occasion of 1500th Birth Anniversary celebrations of Aryabhatta in New Delhi during November 2-4, 1976. Dr. P. K. Raju participated in the workshop on Atomic and Molecular Collisions at Ahmedabad during October 4-18, 1976 and gave a review talk on applications of Atomic Physics to Astrophysics. Dr. K. R. Sivaraman attended the 64th Session of Indian Science

Congress at Bhubaneswar during January 3-7, 1977 and gave an invited review talk on "Magnetic characteristics of the Active Sun".

Dr. R. K. Kochhar attended the symposium on Plasma Physics and its applications at P. R. L., Ahmedabad during August 10-17. 1976. Drs. J. H. Sastri and Mahipal Singh participated in the space sciences symposium during January 17-22, 1977 at VSSC, Trivandrum.

Dr. D. C. V. Mallik attended the 16th General Assembly of IAU in Grenoble during August 24-September 2, 1976 and also IAU symposium No. 75 on "Star Formation", in Geneva during September 6-10, 1976. He also gave an invited review on "Molecules in the Interstellar Medium" at the Bhubaneswar Session of the Indian Science Congress.

VISITING SCIENTISTS

Scientists who visited the Institute and its field stations and who gave colloquia include Prof. Merx, Department of Atomic Physics, University of Budapest, Dr. Ergma E. V, Academy of Sciences, USSR, Dr. Hasegawa of Bell Laboratories, U. S. A., Dr. S. M. R. Ansari of the Aligarh Muslim University, Dr. S. M. Chitre of the Tata Institute of Fundamental Research, Dr. A. Peraiah, of the Institute of Theoretical Astrophysics, Heidelberg, and Dr. Murray Dryer of the National Oceanographic and Aeronautic Agency, U. S. A.