

ANNUAL REPORT\* OF THE KODAIKANAL OBSERVATORY FOR  
THE YEAR 1965

*Solar Physics*

The analysis of the molecular line profile data obtained in the previous year is now complete. Assuming a known doublet separation, computed profiles for 3864Å and 4207Å of CN and 5094Å of C<sub>2</sub> give a satisfactory fit with the observations for a value of 3 km/sec. radial turbulent velocity at the disc centre. For other positions on the disc from centre to limb, the most reasonable fits obtained are for a tangential turbulent velocity of 3.6 km/sec. The mean optical depths of the lines range in the interval 0.04 to 0.10.

The total radiation from the sun was measured photoelectrically during the annular solar eclipse of 23rd November, 1965, in the spectral region at 5300 Å to determine the limb darkening of the Sun very close to the limb. The observations were taken at Bagdogra, in West Bengal.

Simultaneous spectra of the H-alpha line in the third order and calcium K-line in the fifth order were obtained on the solar disc with the 18-metre spectrograph, to study the relative disc features in the two lines.

Spectra of the H-alpha line in the fourth order of the 18-metre spectrograph were obtained at slit positions on the solar disc at  $\mu=1.0$ ,  $\mu=0.8$ ,  $\mu=0.6$ ,  $\mu=0.4$  and  $\mu=0.3$  to study the characteristics of the chromospheric mottling on the solar disc.

The solar magnetometer, constructed in the Observatory, for the detection of weak magnetic fields on the solar surface was used to obtain measures of weak longitudinal fields of the Sun. The instrument was also used in the velocity mode to record velocity fields of selected regions on the Sun.

Magnetic field measures of sunspots were obtained on 81 days during the year. These were made photographically using the FeI line at 6303Å.

The Sun was photographed in white light on 323 days as against 332 days in 1964; H-alpha disc, K-disc and K-prominence spectroheliograms were secured on 268, 290 and 272 days respectively, as against 282, 290 and 268 days respectively in 1964. H-alpha filtergrams of the disc and prominences with the Lyot heliograph were obtained on 230 days as against 256 days in 1964. The total number of exposures of each kind was as follows:

1. Photoheliograms	...	416
2. H-alpha spectroheliograms	...	732
3. K <sub>232</sub> spectroheliograms	...	842
4. K-Prominences	...	528
5. K <sub>1</sub> spectroheliograms	...	158
6. H-alpha Prominences	...	88

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\*This report deals chiefly with the astronomical and allied geophysical work of the Kodaikanal Observatory. The Meteorological data will be published in the Indian Weather Review, the Seismological data in the Seismological Bulletin and the Administrative details in the Administration Report of the India Meteorological Department.

Observations with the spectrohelioscope were made on 298 days covering a total duration of 1120 hrs. of patrol. 10 solar flares were observed during the year, 6 of importance 1— and 4 of importance 1. The data provided by the routine solar observations have been sent regularly to the World Data Centres.

Observing conditions were more or less the same as in the previous year. The average definition of the Sun's image was 3 on scale of 5. The north dome recorded 46 days of seeing 4 and 179 days of seeing 3. The total rainfall recorded was 1369 mm. which was 18.9% below the annual normal. The total number of hours of sunshine was 1804.

There has been a slight increase in sunspot activity during the year. The mean equatorial distance of northern hemisphere spot groups was  $23^{\circ}.3$  and of the southern hemisphere spot group  $20^{\circ}.9$  as against  $16^{\circ}.2$  and  $7^{\circ}.4$  in 1964. Details of the sunspot observations are given in the following table.

1965	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total mean
No. of new spot groups	N 7	3	6	5	7	3	6	4	5	2	4	7	59
	S —	2	—	2	—	3	—	2	—	3	—	1	13
Mean daily No. of spot groups	1.2	1.2	0.7	0.6	1.3	0.7	1.0	0.5	1.1	1.1	1.2	1.0	1.0
Kodaikanal daily relative sunspot number	17.9	13.8	10.1	8.2	22.7	13.5	18.7	8.8	18.0	20.0	20.3	21.3	16.1

The following table gives the mean daily area and number of calcium prominences at the limb as derived from spectroheliograms obtained at Kodaikanal during 1965.

1965	Area (Sq. minutes)					Number				
	N	S	E	W	Total	N	S	E	W	Total
January— June	1.43	0.46	0.90	0.99	1.89	3.04	1.48	2.24	2.28	4.52
July— December	1.97	0.91	1.41	1.47	2.88	3.54	1.84	2.66	2.72	5.38
Whole year (weighted mean)	1.66	0.66	1.12	1.20	2.32	3.25	1.64	2.43	2.46	4.89

The figures show a slight increase in activity of area and slight decrease in number, the increase in area being 4.5% and the decrease in number being 24.9%. The distribution of areas in the northern hemisphere in five degree ranges of latitude shows a peak of activity extending from  $40^{\circ}$ — $55^{\circ}$ . In the southern hemisphere the peak activity is in the latitude belt  $35^{\circ}$ — $45^{\circ}$ .

The mean daily area and number of hydrogen absorption markings on the disc as obtained from Kodaikanal records are as follows:—

1965	H—alpha dark marking area (in millionths of the Sun's visible hemisphere uncorrected for foreshortening)					Number				
	N	S	E	W	Total	N	S	E	W	Total
January— June	1078	133	625	586	1211	8.09	1.30	4.69	4.70	9.39
July— December	1260	305	768	797	1565	10.12	2.66	6.55	6.23	12.78
Whole year weighted mean	1157	208	687	628	1365	8.99	1.89	5.51	5.37	10.88

Compared to the previous year there is a decrease of activity of the absorption markings judged both by areas and numbers. The decrease in area amounted to 27.4% while the decrease in number was 24.1%. In the northern hemisphere the peak activity is in the latitude belt  $45^{\circ}$ — $60^{\circ}$  and also in the zone  $25^{\circ}$ — $35^{\circ}$  and in the southern hemisphere it is in the zone  $15^{\circ}$ — $25^{\circ}$ .

The exchange of spectroheliograms with foreign observatories was continued. For the period July 1964 to June 1965, 77 H-alpha disc, 52 K-disc and 62 K-Prominence Spectroheliograms were received from the Meudon Observatory. 76 H-alpha disc and 130 K-disc spectroheliograms for certain days for the period 1964-65 were sent to the Meudon Observatory.

#### *Stellar Physics*

An order was placed with VEB Carl Zeiss, Jena for a one metre reflecting telescope.

Low dispersion spectra of the Wolf-Rayet spectroscopic binary Gamma Velorum suggest a period for the system larger than the 16-day period suggested by Gaposchkin. Further observations of this system are in progress. Spectra have also been obtained of VV Orionis and Delta Orionis for radial velocity measures.

Photoelectric Photometry of variable stars with the 20 cm. Cooke refractor has been continued. Observations currently in progress are of the eclipsing systems 29 Canis Majoris, YY Eridani and VV Orionis.

Photoelectric observations of polarisation of the coma of Comet Ikeya-Seki (1965f) were made through narrow band filters that isolated the emission bands at 3888A and 4737A as well as the continuum at 4290A and 5890A. Flux measures of the Comet at 3888A, 4290A, 4737A, 4861A and 5890A were also made.

Low dispersion slit spectra as well as prismatic spectra in the blue and visual regions of the comet were obtained during the period October 13—November 4.

A Blink Star plate comparator which forms a potential tool for the study of proper motions, variable stars and allied branches of stellar physics was procured from VEB Carl Zeiss, Jena. About 40 acres of land at Kavalur in the Javadi Hills, North Arcot District, Madras State was acquired from the Forest Department for the proposed field station of the Kodaikanal Observatory.

*Geomagnetism, Ionospheric Physics and Solar-Terrestrial Relationships*

Geomagnetic sudden commencement data obtained at several middle and low latitude stations during the IGY/IGC and subsequent years have been examined with a view to explain the occurrence of storm sudden commencements of abnormally large amplitude and short rise times. The optical, radio emission and the energetic particle characteristics of the source flares, configuration of the interplanetary magnetic fields and conditions in the vicinity of the magnetic boundary have been examined. It has been found that all storm sudden commencements of amplitude above a threshold minimum at a given middle latitude station are associated with energetic proton events. East-West asymmetry and centre-limb variation in propagation times of storm plasma have also been found to exist. The day time enhancement of SC amplitudes in the boundary of magnetic equator, has been ascribed to smaller attenuation of the hydromagnetic waves from the magnetospheric boundary as they travel through the equatorial ionosphere, because of very low number density of positive ions at great heights associated with vertical divergence of ionization near dip. equator. The SC amplitude characteristics have been utilized to identify about 50 solar proton events during sunspot cycles 12 to 18.

A study of some aspects of flare-geomagnetic storm associations has been in progress. An investigation in regard to some chief features of the annual variation in E-region ionization has been made.

IGY-IGC data of ionospheric parameters for Kodaikanal and Huancayo were analysed to study the equatorial electrojet. The electrojet width and strength are small in East and Far East as compared to Huancayo. Ionospheric irregularities such as spread F and blanketing ES show a greater tendency of occurrence in Kodaikanal than in Huancayo. Frequency of occurrence of blanketing type of Es at Kodaikanal is maximum in summer. This type of Es produces reduction in the intensity of the horizontal force. The presence of the blanketing type of Es increases the critical frequency of the F<sub>2</sub> layer. The range of variation of h<sub>p</sub> F<sub>2</sub> from sunspot minimum to maximum is smaller in Kodaikanal than at Huancayo. This has been attributed to the frequent occurrence of blanketing Es at Kodaikanal during sunspot maximum.

Continuous recordings of H, D and Z elements of the Earth's magnetic field with Watson and La Cour magnetographs and Askania Field Balances have been continued. Absolute values of H, D and Z have been determined weekly with a set of QHM and BMZ instruments. During the year 19 geomagnetic storms including 13 storms of sudden commencement type, have been recorded at Kodaikanal with ranges in horizontal force between 90  $\gamma$  and 372  $\gamma$ .

Regular vertical incidence soundings of the ionosphere and registration of short-wave field strength have been continued. Regular observations have been made of Faraday fading of 40 and 41 Mc/s transmissions from the NASA Ionospheric Polar Beacon Satellites, Explorer 22 and Explorer 27 for

the measurement of total electron content  $n_T$  in the equatorial ionosphere. Regular measurements of total magnetic field at Kodaikanal using a proton precession magnetometer have commenced from October, 1965.

Monthly median values of foF<sub>2</sub> and (M3000) F<sub>2</sub> have been supplied to the Central Radio Propagation Laboratory, Boulder, Colorado, U.S.A. Quarterly statements of monthly median values of all ionospheric parameters have been sent as in previous years to Radio Research Station, U.S.A. Periodical statements of observational data concerning ionospheric characteristics, geomagnetic storms and ionospheric disturbances have been supplied to several interested institutions. Daily messages in IGY codes relating to solar, magnetic and ionospheric observations at Kodaikanal have been sent to New Delhi for inclusion in the AIMBC broadcasts.

#### *Radio Astronomy*

Regular recordings of solar noise flux on a frequency of 100 Mc/s were continued. Scintillation observations of radio sources Cygnus A and Cassiopeia were made whenever possible. Jupiter radio radiation recordings at a frequency of 22.2 Mc/s were resumed in May, 1965 when night observations of Jupiter became possible.

The design and construction of a 20-120 Mc/s dynamic solar radio spectrograph has been in progress. A two metre paraboloid for use with a 10 cm radiometer for solar patrol has been designed and the construction of it completed.

#### *Optical Workshop*

A fully automatic optical machine for handling surfaces up to 92 cm. diameter was designed and constructed. An eight inch cassegrain telescope was designed and the construction was completed. Considerable progress was made in the construction of the 70 cm. aluminising plant.

#### *Miscellaneous Observations*

Routine ozone, meteorological, seismological and radiation observations have been carried out as in previous years.

#### GENERAL

Two of the research students in residence were awarded the Ph.D. degrees of the Agra and Madras Universities.

#### PUBLICATIONS

- |   |   |
|---|---|
| Bappu, V. M. K.<br>Doss, A. T.<br>Viswanadham, P. | Photoelectric observations of the 1963-64 Eclipse of Zeta Aurigae—The Observatory, Vol. 85, 1965.   |
| Bhargava, B. N.                                   | Seasonal and Longitudinal F <sub>2</sub> region anomalies in relation to occurrence of blanketing sporadic E—Journal of Atmospheric and Terrestrial Physics, Vol. 27, 1965. |
| Ganesh, K. S.                                     | Solar cycle and seasonal variations in the Equatorial Ionospheric F region — Journal of Atmospheric and Terrestrial Physics — Vol. 27, 1965.                                |

- Narayana, J. V. Active prominences and associated terrestrial effects — Kodaikanal Observatory Bulletin No. CLXV, 1965.
- Narayana, J. V.  
Viswanadham, P. The light curve of the short period variable SX Phoenicis — Kodaikanal Observatory Bulletin No. CLXX, 1965.
- Ramanathan, A. S.  
Natarajan, V. Some characteristics of sunspot activity within a cycle — The Observatory, Vol. 85, 1965.

KODAIKANAL OBSERVATORY

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