ANNUAL REPORT* OF THE KODAIKANAL OBSERVATORY FOR THE YEAR 1961

Solar Physics

The Solar Tower telescope and spectrograph have been used actively until September 1961 for a study of the Evershed Effect in sunspots and for the structural aspects of the K_2 emission in plages. During this period it became apparent that certain large scale modifications of the building, dome and spectrograph have to be effected before embarking on investigations making use of the full possibilities of the instrument. Accordingly, the coelostat has been completely dismantled and the observing floor raised by six feet to enable the commencement of solar observations soon after sunrise, when Kodaikanal has generally the best 'seeing'. A new 20-foot diameter dome has been under construction in the observatory workshop.

A narrower pass band interference filter transmitting 60 Å has been put in use with the Coronagraph in place of the 120 Å filter. This has given improved pictures of prominences. Considerable experimentation has been done on a suitable dispersion spectrograph for use with the coronagraph. The spectrograph now in use has a curved slit, made in our workshop and a double dispersion arrangement using two speculum gratings.

Regular observations with the Lyot Monochromatic heliograph have been continued and filtergrams have been obtained of the disc and prominences on 304 days. Commencing from January 1, 1961, the photographic and visual patrol with the H-alpha heliograph and the spectrohelioscope have been intensified and the solar chromosphere is now under surveillance from 0130 GMT to 1130 GMT every day. The 10-hr. watch covers the vital longitude gap in the global solar patrol. It has also increased the total number of flares observed at Kodaikanal.

Observations with the older instruments have been continued. Photoheliograms were taken on 309 days compared to 286 days in 1960. H-alpha disc, K-disc and K-prominence spectroheliograms were secured on 238, 305 and 264 days as against 232, 251 and 234 days respectively during 1960. The total number of exposures of each kind was as follows :

1.	Photoheliograms	432
2.	H-alpha spectroheliograms	547
3.	K_{2v2} spectroheliograms	921
4.	K-prominences	544

Observations with the spectrohelioscope were made on 288 days covering a total duration of 1103 hours. 89 solar flares were observed during the year, three of importance 2, six of importance 1+, twentyeight of importance 1 and 52 of importance 1−.

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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 India Weather Review, the Seismological data in the Seismological Bulletin and the administrative details in the Administrative Report of the India Meteorological Department.

Observing conditions

Observing conditions were generally better than in the previous year. The average definition of the sun's image was 3 on a scale of 5. There were 12 days of seeing 4 and 192 days of seeing 3. The total rainfall recorded was 1466 mm which was about 14% less than the annual normal. The total number of hours of sunshine was 1609.

Sunspot activity

There was a further decline in Sunspot activity during the year. The mean equatorial distance of the northern hemisphere spot groups was 10°.9 and of the southern hemisphere spot groups 10°.3 as against 14°.5 and 12°.7 in 1960. Details of sunspot observations are given in the following table :

		Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total mean
No. of new spot groups	N	8	3	11	8	5	8	12	11	11	12	9	9	107
	S	10	6	14	10	2	10	6	10	1	4	2	2	7
Mean daily No. of spot groups		3.6	3.2	3.5	4.0	2.1	3.9	3.6	2.6	2.8	2.7	1.9	2.2	0
Kodaikanal daily relative sunspot numbers		63.0	46.1	50.6	60.5	32.9	63.4	53.5	37.0	50.8	35.0	23.1	33.3	45.8

Prominences

The mean daily areas and numbers of calcium prominences at the limb as derived from photographs obtained at Kodaikanal are given below :

Prominences 1961	Area (in square minutes)					Number				
	N	S	E	W	Total	N	S	E	W	Total
January—June	2.54	2.36	2.26	2.64	4.90	4.59	4.19	4.18	4.60	8.78
July—December	2.06	2.58	2.39	2.25	4.64	5.17	5.85	5.64	5.38	11.02
Whole year (weighted mean)	2.31	2.47	2.32	2.46	4.78	4.85	4.95	4.85	4.95	9.80

Compared with 1960 there was a slight increase in prominence activity the increase in area being 3.3 per cent and in numbers 14.6 per cent.

The distribution of areas in the northern hemisphere in five-degree ranges of latitude showed a broad peak of activity extending from 20°—35°. In the southern hemisphere the maximum activity was in the zone 10°—20° with a secondary maximum in the latitude belt 50°—55°.

Fifteen sudden disappearances of dark absorption markings and limb prominences were observed during the year.

The mean daily areas and numbers of hydrogen absorption markings on the disk as obtained from Kodaikanal records were as follows :

1961	H-alpha dark marking area (in millionths of the sun's visible hemisphere uncorrected for foreshortening)					Numbers				
	N	S	E	W	Total	N	S	E	W	Total
January–June	1870	1252	1489	1633	3122	11.0	7.6	9.3	9.3	18.6
July–Decr.	2166	1473	1865	1744	3639	15.9	10.3	12.4	13.8	26.2
Whole year (weighted mean)	1977	1331	1624	1684	3308	12.7	8.6	10.4	10.9	21.3

Compared to the previous year there was considerable decrease in the activity of the absorption markings judged both by areas and numbers. The decrease in area amounted to 39.8 per cent while the numbers showed a decrease of 34 per cent. In the northern hemisphere the peak of activity was in the latitude belt 20°—25° whereas in the southern hemisphere the maximum activity was in the zone 15°—20°.

The exchange of spectroheliograms with foreign observatories was continued. For the period July 1960 to June 1961, 135 H-alpha disc, 133 K-disc and 133 K-Prominence spectroheliograms from the Meudon Observatory and 86 H-alpha disc, 83 K-disc and 94 K-limb spectroheliograms from the Mount Wilson Observatory were received. 82 H-alpha disc and 127 K-disc and 1 K-Prominence spectroheliograms for certain days for the period 1959-'61 were sent to the Meudon Observatory on request. Copies of daily spectroheliograms were supplied regularly to the Fraunhofer Institute, Germany for the preparation of daily solar maps. 13 Photoheliograms together with the relevant zero plates for certain days in 1960-61 were supplied to the Astronomer Royal, Royal Greenwish Observatory, England. Central meridian passage of important sunspots were communicated to interested institutions in India. Quarterly statements relating to Solar flares were sent as in previous years to the Meudon Observatory and to the Royal Greenwich Observatory.

Bappu and Punetha have completed an investigation of the stability of spatial distribution of the magnetic field in the chromosphere during solar flares based on Kodaikanal calcium spectroheliograms obtained during flares of importance 3 or greater. It is seen that the field distribution remains unaffected for values greater than 20 gauss in the region of the flare.

The solar flare effects on dark filaments and the striation pattern in the vicinity of the flare are being studied by Bhatnagar and Punetha for events having well exposed sequence spectroheliograms in the Kodaikanal collection. It is seen that the striation network for intense flares presents a veiled appearance the extent of which is controlled by changes in flare area and pattern.

Bappu and Narayana undertook a study to find out the changes, if any, in the integrated light of the sun during the course of a sunspot cycle. As the integrated light changes should be detectable by analysing the characteristics of monochromatic radiations, a photometric investigation of the total radiation emitted from the solar surface by the monochromatic K line of a few selected Kodaikanal spectroheliograms obtained at sunspot maximum and minimum has been made. It has been found that the change in total radiation emitted by the K-line during a cycle has a measurable value of about 0.1 magnitude.

Miss Subrahmanyam has commenced a study of motions of knots in eruptive prominences for which sequence spectroheliograms are available in the Kodaikanal collection. Detailed analysis have been completed for two events of the eight selected for study.

Narayana investigated the association of active prominences with solar noise bursts and some geophysical events and found that Solar prominences of high activity are also likely sources of enhanced solar radio-radiation and X-rays.

Radio Astronomy

Regular recording of solar noise flux at a frequency of 100 Mc/sec. has been continued. A 6-metre aperture paraboloid with an equatorial mounting for radio astronomical studies in the centi metre wavelength region has been constructed. Scintillation observations of Cygnus A and Cassiopeia have been made, whenever possible, for a co-ordinated study of spread F, geomagnetic activity and radio-star scintillation at low latitudes.

Stellar Physics

The principal telescope available at Kodaikanal is the 20-inch Bhavnagar reflector. Some alterations have been made in the optical layout of this telescope as a result of which a f/18 Nasmyth focus is now available for spectrographic work. A grating spectrograph having a dispersion of 9Å° mm has been installed at that focus for stellar spectroscopy and several satisfactory high dispersion spectra have been obtained of the brightest stars in the southern hemisphere. A double slide plate-holder for direct photography at the Newtonian focus of the telescope has also been completed.

Geomagnetism and Ionospheric Physics

Continuous photographic recording of H, Z and D elements with the aid of Watson and La Cour magnetogrphs and visible recording of H and Z with Askania field balances have been continued. Absolute values of H, D and Z have been determined every week with a set of QHM and BMZ instruments. Absolute measurements of H with a Kew Magnetometer and of inclination with a Schulze Earth Inductor have also been made once every month.

Scale value determinations of these magnetographs have been done twice a month. During the year 17 magnetic storms including 13 storms of the sudden commencement type were recorded with ranges in horizontal force between 88 γ and 452 γ. Quarterly magnetic storm data have been sent to Prof. John A. Simpson of the University of Chicago.

Routine Ionospheric soundings have been made once in every 15 minutes throughout the year except during power failures or malfunctioning of the equipment which accounted for 426 hrs. during the whole year. Short-wave field intensity recordings have been made during day-light hours on all days of the year. Short-wave radio fadeouts of Dellinger type have been recorded on 18 occasions. Round-the-clock recordings of Cosmic noise at 30 Mc/sec. were made daily from July 1961 onwards; on four occasions SCNAs were recorded.

Monthly median values of fo F2 and (M3000)F_2 have been supplied to the Central Radio Propagation Laboratory, Boulder, U.S.A. Quarterly statements of monthy median values of all ionospheric parameters have been sent as in previous years to the Radio Researh Station, Slough, England and CRPL, Boulder, Colorado, U.S.A. Periodical statements of observational data concerning ionospheric parameters, geomagnetic storms and sudden ionospheric disturbances and forecasts of expected magnetic and ionospheric disturbances have been supplied to several interested institutions. Daily messages in I.G.Y. code relating to solar, magnetic and ionospheric observations at Kodaikanal have been sent to New Delhi for inclusion in the AIMBC broadcasts.

Bhargava and Subrahmanyan have analysed the ionospheric and geomagnetic data obtained at Kodaikanal during the cosmic ray solar flare of February 23, 1956 for a study of the changes in the ionospheric F-region associated with this flare.

Bhargava and Saha examined the Kodaikanal ionograms obtained during the last ten years for the selection of the ionograms having extraordinary features of interest for publication in the form of an atlas of equatorial ionograms.

Bhargava has investigated the lunar tidal effects on the first appearance and final disappearance of E_s (q). The study reveals that E_s (q) appears earlier in the vicinity of new and full moon by about 22, 25 and 26 minutes for summer, winter and the equinoxes respectively than in the first and third quarters. As regards the final disappearance at sunset there appears to be a tendency for late disappearance round about first and third quarters, particularly during winter. For other seasons no conclusions can be drawn due to the vitiating effects of day-time blanketing E_s.

A study of the effects of severe geomagnetic storms recorded at Kodaikanal during the I. G. Y. (1957-58) was completed by Subrahmanyan. His results show that during the main phase of most intense storms, when the Kodaikanal H-component becomes abnormally low, stratification in the day-time thick F-region develops; a close relationship between the annihilation of E_s (q) and the formation of storm stratification in F-region with a mean delay of about 2½ hrs. has also been found. The nocturnal F-layer ionic densities on such occasions have been found to be abnormally high.

Bhargava and Subrahmanyan have made evaluations of attachment-like loss coefficient at several fixed heights of ionospheric F-region from (N,h) profiles by a comparatively simple method and these have been shown to yield reasonable values of loss coefficient. They have examined the seasonal characteristics of the loss coefficient and their relation with concentration of the atomic and molecular gases. From analysis at average heights of maximum electron densities, seasonal and solar cycle changes in the loss coefficient in ionospheric F-region for several latitudes have also been obtained and discussed by these authors.

Sankaran has made a study of cusps and distortions in F1 layer traces from ionograms obtained at Kodaikanal through a period of about half a solar cycle. Two different types of disturbances have been noticed; the first one is of a stationary type observed near the low frequency end of F1 layer trace and is attributed to be related to E_2 cusps. In the second type of disturbance, the cusps appear to move up along the virtual height curves. It is also found that this second type of disturbance, is generally associated with disappearance of equatorial E_s on magnetically disturbed days. The occurrene of the travelling wave-type disturbance has been interpreted in terms of internal gravity waves in the ionosphere, proposed by Hines.

Miscellaneous Observations

Meteorological observations with the visual and self-recording instruments have been carried out as usual. Cosmic ray observations with the Kolhorster apparatus were discontinued.

The Milne-Shaw Seismograph recorded 108 earthquakes. Regular observations of atmospheric ozone have been made with the Dobson Ozone Spectrophotometer on 253 days. Earthshine observations were recorded on 21 days.

Instrumental development

A high quality Babcock grating has been received on loan from the Mount Wilson and Palomar observatories. This grating will be used with the high dispersion 18 metre spectrograph of the solar tower. The designing of a vertical all mirror spectroheliograph for the study of spatial magnetic fields and Doppler effects is well under way.

An all mirror image rotator that gives uniform illumination over 3 cm of the slit of the 18 metre spectrograph has been completed.

The old Cambridge microphotometer has been remodelled and brought into use. It now utilises a photomultiplier tube as the light receiver, the current output of which is registered on a Brown recorder.

An improved converter for 100 Mc/sec. radiometer has been constructed using a new G. E. C. low-noise triode A 2521. The development of an improved 200 Mc/sec. converter has also been undertaken. Work on an interferometric aerial for scintillation work at 5 metre wavelength has been started. A 20-foot paraboloid for work at wavelengths in the decimetre and metre range has been set up on an equatorial mounting.

A 12-inch aperture spherical mirror has been ground and polished in the optical shop. Work has also progressed satisfactorily on an 8-inch Cassegrain telescope.

General

The Director attended the Eleventh General Assembly of the International Astronomical Union held at Berkeley, California and visited some observatories in the U.S.A.

The Director and Assistant Director attended the Cosmic Ray Symposium held at Madras during the 3rd week of December 1961.

Visitors

The Prime Minister of India visited the Observatory on October 6. Dr. S. Chandrasekhar, Distinguished Service Professor of the University of Chicago visited the observatory in November.

Publications

Bhargava, B. N. & Subrahmanyan, R. V. — Geomagnetic disturbance effects in equatorial Es—Journal of Atmospheric & Terrestrial Physics Vol. 20 No. 1 (1961)

Bhargava, B. N. & Subrahmanyan, R. V. — A study of the pre-sunrise F-layer stratification at Kodaikanal—Proceedings of the Indian Academy of Sciences Vol. L III No. 5 Sec. A (1961).

Subrahmanyan, R. V. See Bhargava, B. N.

Quarterly synopses of results of solar, magnetic, ionospheric and ozone observations made at Kodaikanal appeared in the Indian Journal of Meteorology and Geophysics. The Monthly Notices of the Royal Astronomical Society published a report of the work done at Kodaikanal Observatory during 1961 as well as on the prominence activity during the same year.

Kodaikanal Observatory,
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Director.

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