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GOVERNMENT OF INDIA
DIRECTOR-GENERAL OF OBSERVATORIES

ANNUAL REPORT
OF THE
KODAIKANAL OBSERVATORY
FOR THE YEAR
1960
(1881-1882 SAKA)

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Introduction

The Solar Telescope & Spectrograph, the Coronagraph and H-alpha Heliograph were formally inaugurated by Dr. P. Subbarayan, Union Minister for Transport and Communications on the 14th September, 1960.

Solar Physics

After a period of tests and preliminary adjustments the 18 metre spectrograph employing a Bausch & Lomb grating has been brought into use in conjunction with the 36 metre solar telescope. Some plates have been taken of a few spots for the study of the Evershed Effect. The instrument has also been used for the investigation of the structure of the H & K lines in the vicinity of sunspots. A fifty year old series of spectra covering half a solar cycle obtained by Evershed at Kodaikanal, provides additional material for the investigation.

Regular observations with the Lyot monochromatic Heliograph were commenced and filtergrams were obtained of the disk and prominences on 127 days. Exposures in rapid sequence are taken during the progress of a solar flare.

First observations with the 20cm. coronagraph of prominences have been made towards the end of the year. An interference filter having a width at half intensity of 120 Å isolates the region around H-alpha for obtaining prominence photographs on 35mm. film.

Observations with the older instruments have been continued. Photo heliograms were taken on 286 days, compared to 260 days in 1959. H-alpha disc, K-disc and K-prominence spectroheliograms were secured on 232, 251 & 234 days as against 244, 235 & 224 days during 1959. The total number of exposures of each kind was as follows :--

1. Direct photographs	286
2. H-alpha spectroheliograms of Flare regions	8
3. H-alpha spectroheliograms of entire disc	624
4. K-232 spectroheliograms	675
5. K-Prominences	548

Observations with the spectrohelioscope were made on 270 days covering a total duration of 462 hours. Nineteen solar flares were observed during the year, three of intensity 3, nine of intensity 2 and seven of intensity 1.

*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 about average during the year. The total rainfall recorded was 1861.3mm. which is slightly less than the annual normal. The total number of hours of bright sunshine was 1852.7.

The average definition of the sun's image was 3 on a scale of 5. There were seventeen days of seeing 4 or better and one hundred and sixty three days of seeing 3.

Sunspot activity

Sunspot activity continued to be on the decline throughout the year. The mean latitude of all the observed spotgroups in the northern and southern hemispheres was 14.5° and 12.7° as against 15.4° and 13.3° in 1959. Details of sunspot observations are given in the following table:—

Months	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep	Oct.	Nov	Dec.	Total	
No. of New Spot Groups	N	27	7	21	17	18	19	13	13	14	20	12	18	199
	S	15	9	8	6	13	8	9	13	17	10	7	15	130
Mean daily No. of Spot Groups.	8.6	6.2	6.0	5.7	6.9	6.0	5.1	4.4	7.6	6.2	3.7	5.5	6.0	
Kodaikanal daily relative sun-spot number.	145.3	101.3	114.2	115.5	113.4	106.7	94.9	122.2	121.3	106.6	63.3	93.4	108.1	

Prominences

During 1960 prominence activity continued to be high. The mean daily areas and numbers of calcium prominences at the limb as derived from photographs obtained at Kodaikanal were as follows :—

1960	Area in square minutes of arc.					Numbers				
	N	S	E	W	Total	N	S	E	W	Total
January-June	2.17	1.55	1.75	1.97	3.72	4.06	3.00	3.47	3.59	7.06
July-December	3.26	2.67	2.89	3.04	5.93	5.58	5.14	4.76	5.96	10.74
Whole year (weighted mean).	2.62	2.01	2.21	2.42	4.63	4.68	3.87	4.00	4.55	8.55

Compared to 1959 there has been no appreciable change in prominence activity, from the standpoint of areas, even though the numbers show a slight decrease amounting to 2.3 per cent.

The distribution of areas in the northern hemisphere, in five-degree ranges of latitude showed a broad peak of activity in the zone 20°-30°, with a secondary maximum in the zone 35°-40°. In the southern hemisphere there was a well-marked maximum in the latitude belt 5°-10°. The activity in the southern hemisphere continued to be less than in the northern.

Six instances of 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 are given in the following table:—

1960	H-alpha darkmar king Area (in mil. i- onths of sun's visible hemisphere uncorrected for fore-shortening)					Numbers				
	N	S	E	W	Total	N	S	E	W	Total
January-June .	3548	2110	2747	2911	5658	19.71	13.14	16.66	16.19	32.95
July-December .	3175	2074	2373	2876	5249	19.10	12.47	16.30	15.27	31.57
Whole year weighted mean).	3395	2094	2594	2895	5489	19.46	12.87	16.51	15.82	32.33

Compared to the previous year the activity, as judged by areas showed an increase of 13.2 per cent and the numbers increased by 7.6 per cent. The peak of activity in the northern hemisphere, both in areas and numbers, was in the belt 20° - 25° whereas in the southern hemisphere the maximum activity was confined to the zone 10° - 15° . The western preponderance in area shown by limb prominences is also evident from the area of absorption markings.

The exchange of spectroheliograms with the foreign observatories was continued. For the period July 1959 to July 1960, 95 H-alpha disc, 111 K-disc and 111 K-prominence spectroheliograms from the Meudon Observatory and 73 H-alpha disc, 98 K-disc and 99 K-limb spectroheliograms from the Mount Wilson Observatory were received. 73 H-alpha disc and 11 K-disc spectroheliograms for certain days for the period 1959-1960 were sent to Meudon Observatory on request. Copies of daily spectroheliograms (disc in H-alpha and K and limb in K) were supplied in fortnightly batches to the Fraunhofer Institute, Germany, for the preparation of daily solar map. Quarterly statements relating to solar flares were sent, as in previous year, to the Meudon Observatory and to the Royal Greenwich Observatory. Central meridian passages of important sunspots were communicated to interested institutions in India.

Radio Astronomy

The 100 Mc/s Solar Noise Receiver has been modified to yield an improved performance and regular recording of solar noise flux at this frequency has been continued. Interferometers operating at 60 Mc/s and 200 Mc/s are being set up to facilitate continuous recording of solar noise at two more frequencies. Scintillation recordings of Cygnus A at 100 Mc/s were made for a coordinated study of spread-F, geomagnetic activity and radio-star scintillation. A scheme is under preparation for the starting of a small field station to the south of Kodaikanal for radio-star scintillation recording at two wavelength in the metre-wavelength region. The project

aims at the study of that region of the ionospheric F-layer by radio-astronomy methods which is observed over Kodaikanal, by h'f technique. Preliminary designs have been completed of a 50 feet diameter paraboloid for use as a transit instrument. The smallest wavelength which the paraboloid is designed to receive is 10 cm.

Stellar Physics

Reductions of H-gamma observations carried out at Naini Tal in 1958 and 1959 have been completed. Wavelengths and line intensities in the yellow and red region of the spectrum of the nucleus of Campbell's hydrogen envelope star are being measured using a spectrum taken recently at Mount Wilson on the 100" reflector by Dr. O. C. Wilson.

Geomagnetism and Ionospheric Physics

Continuous photographic recording of H, Z & D elements with the aid of Watson and La Cour magnetographs and visible recording of H and Z with Askania Field Balances were continued. Absolute values of H, D and Z were 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 were also made once every month. Scale value determination of these magnetographs were done twice a month. During the year thirty-three magnetic storms including twenty-six of the sudden commencement type were recorded with ranges in H.F. between 170% and 649%. Quarterly magnetic storm data were sent to Prof. John A. Simpson of the University of Chicago.

The C 3 Ionosphere Recorder functioned continuously on all days of the year and only about 70 hours of observations were lost due to power failure. The daily programme was confined to records every fifteen minutes. Some rapidly changing characteristics at sunrise were followed with the aid of soundings made at 5 minute intervals. Shortwave field intensity values were recorded during the day-light hours on all days of the year. Shortwave radio fade-outs (of Dellinger type) were recorded on 56 occasions. The Observatory continued to supply monthly median values of foF₂ and (M3000)F₂ to the Radio Research Committee of India and the Central Radio Propagation Laboratory, U.S.A.

Quarterly statements of monthly median values of all ionospheric parameters were sent to both the Radio Research Station, Slough and Central Radio Propagation Laboratory at Boulder.

Periodical statements of observational data concerning ionospheric parameters, geomagnetic storms and sudden ionospheric disturbances and forecasts of expected magnetic and ionospheric disturbances were supplied to several interested institutions.

(i) A study of the pre-sunrise F layer stratification at Kodaikanal

Bhargava and Subrahmanyam have investigated the phenomenon of pre-sunrise F layer stratification at Kodaikanal by obtaining (N,h)_z profiles from h'f data of Kodaikanal for many days. This phenomenon, found to occur prominently during periods of low or moderate solar activity and during winter months, is discussed by these authors in terms of distortion of the overhead Sq current intensity and vertical drift of ionization.

(ii) *Geomagnetic Disturbance Effects in Equatorial Es*

Bhargava and Subrahmanyam have examined the effects of geomagnetic storms on the Equatorial type Sporadic E layer (E_{sq}), the occurrence of which is a common feature during day-time at Kodaikanal under normal conditions. They find that the disappearance of E_{sq} is simultaneous with the sudden decrease in the horizontal and vertical components of the earth's magnetic field during the main phase of geomagnetic storms. In their discussion these authors suggest that while the occurrence of the E_{sq} is associated with the intense overhead Sq current system responsible for the quiet-day variation of the earth's magnetic field, its disappearance can be attributed to the opposing influence of the currents responsible for the main phase variations of the earth's field during magnetic storms.

(iii) *Geomagnetic and Sq Current Control on the Diurnal Behaviour of Equatorial F-region*

Bhargava and Subrahmanyam have examined the diurnal behaviour of ionospheric F-region over magnetic equator, using the 24-hourly ionospheric and geomagnetic data obtained at equatorial station of Kodaikanal (Geomagnetic latitude $0^{\circ}6N$; Dip $3^{\circ}5N$). Their study reveals that the observed diurnal variation in the electron density and in the height of the equatorial F-region can be identified with the diurnal variation of electrodynamic vertical tide associated with geomagnetic and Sq Current intensity variations, when due account is also given to the effect of nearly horizontal diffusion of ionization along the geomagnetic field lines from the near "dip" equator to the neighbouring moderately low latitudes.

Miscellaneous Observations

(Ozone, Meteorology, Cosmic-ray, Seismology & Earthshine)

Observations of atmospheric ozone have been continued with the aid of the Dobson Ozone Spectrophotometer. Continuous recording of Cosmic-ray intensity with a Kolhorster Cosmic-ray recorder was continued till November 1960. Earthshine measurements with Danjon's Cat's Eye Photometer were made on 10 days. Routine meteorological Observations were carried out as usual. The Milneshaw Seismograph recorded 59 earthquakes.

Instrumental Development

The 8-inch refractor belonging to the former Madras Observatory has been erected in the "South Dome" on the mounting that carried the prominence spectroscope and 6-inch refractor. Observations with the prominence spectroscope have been discontinued. The 8-inch telescope has been overhauled and renovated for use as a photoelectric telescope. Designs for a photoelectric photometer for use on the 8-inch refractor and of one-prism and two-prism spectrographs for the 20-inch Bhavnagar telescope have been completed.

The Lyot monochromatic heliograph which was originally mounted along with the Lyot coronagraph in the same equatorial has been removed and installed in a separate dome.

Several accessories for use with the new solar installations have been designed during the year. Much progress has been made in the construction of these instruments in the Observatory workshop. These include (1) a spectrohelioscope for selection and guiding of special features, visible in H-alpha radiation, on the slit of the 18-metre spectrograph; (2) an image rotator capable of yielding uniform illumination over a 2-inch slit and (3) a low-dispersion monochromator to act as pre-disperser for the large spectrograph. A mounting is currently being made in the workshop for a concave grating of radius 10 metres to be used in a stigmatic double pass arrangement. A 120 cm. Littrow Grating spectrograph for use on the coronagraph was completed during the year.

International Geophysical Year

The intensive solar observations undertaken during the I.G.Y./I.G.C. were continued during the year and the data were sent to the World Data Centres. Daily messages relating to solar, magnetic and ionospheric observations at Kodaikanal in the I.G.Y. code were sent to New Delhi for inclusion in the broadcasts.

Publications

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- Das, A. K. & Narayana, J. V. Momentary bursts of Cosmic radiation—The Indian Journal of Meteorology & Geophysics, Vol. 11, No. 1 (1960).
- Jayarajan, A. P. See Bhargava, B. N.
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- Srinivasamurthy, B. The diurnal variation of sizes of sudden commencements and impulses in the Kodaikanal magnetograms—The Indian Journal of Meteorology and Geophysics, Vol. 11, No. 1 (1960).
- Subrahmanyam, R. V. See Bhargava, B. N.
- Venugopal, V. R. Temperature of the F-region of the ionosphere over Kodaikanal.—The Indian Journal of Meteorology and Geophysics Vol. 11, No. 2 (1960).

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 1959 as well as on the prominence activity during the same year.

Visitors

Dr. A. G. Wilson of the Rand Corporation, U.S.A., visited the Observatory during the year.

KODAIKANAL OBSERVATORY;
December, 1961.

M. K. VAINU BAPPU,
Director.