

ANNUAL REPORT* OF THE KODAIKANAL OBSERVATORY FOR THE YEAR 1969

SOLAR PHYSICS

Numerous improvements have been made to the prototype solar magnetometer which have increased its operational stability and versatility in the nature of information output. A new detector head has been installed with additional facility of accurate setting on the Fraunhofer lines with varying slit widths. Together with a servo operated Doppler compensator and provision for intensity measures in the core of the line, the instrument yields simultaneously the values of the longitudinal component of the magnetic field, line of sight component of the velocity field and the intensity in the core of the line. Using the magnetometer in this form, several extended runs of the localized granulation-stimulated quasi-periodic oscillations of the solar atmosphere have been obtained over time intervals extending to more than four hours. The extension of these observations to several different lines, ranging from the magnesium 'b' lines of chromospheric origin to lines of atomic carbon that originate from appreciable depths in the photosphere, has enabled inference on the depth dependence aspects of these quasi-periodic oscillations. The results have demonstrated satisfactorily a shorter period of oscillation at high chromospheric heights and provide additional support for the theory that explains random phase changes of the oscillations in terms of random perturbations originating from the hydrogen convection zone. The statistical properties of the bursts of oscillation at different depths have been examined in detail with the CDC 3600. The results imply a more complicated structure of the energy dissipation mechanism than what has been believed hitherto.

A controlled set of observations have also been made with the solar magnetometer to detect possible oscillations of the local longitudinal magnetic field component. Detailed coherence analyses of simultaneous records of magnetic and velocity fields fail to show a variation in the line of sight component of the magnetic field caused by the quasi-periodic oscillation. The result is contrary to the findings of the Crimean observers.

* The report deals chiefly with the astronomical and allied geophysical work of the Kodai-kanal 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.

Three time-sequence spectra of excellent quality were obtained in a quiet region at the centre of the solar disc each lasting for nearly 40 minutes, with the 19 metre spectrograph. The time-sequence spectra are around 6587\AA of Cl , 6347\AA and 6240\AA . These are under analysis to study the spatial properties of the quasi-periodic photospheric and chromospheric oscillations.

A study of solar wind characteristics based on the sodium emission in cometary nuclei was completed. Seventeen comets, having in formation on sodium D-line emission during their apparition were examined. The heliocentric distances corresponding to the commencement or termination epoch of sodium emission are found to have a dependence on the phase of the solar cycle. Comets appearing during a solar maximum show detectable sodium emission to greater distances than comets appearing during a solar minimum. The sodium emission is also found to depend on heliographic latitude of the comet which shows that the change in spatial properties of the solar wind with phase of the solar cycle is responsible for this observed dependence.

The study of the velocity field structure in a super-granule and its evolution was continued by obtaining additional spectra in the 4554\AA B_1^+ line, of a specific location on the Sun for consecutive days. Near-simultaneous K-line spectra and spectra in line 6303 FeI with a double image prism arrangement provided a picture of the chromospheric net work and the distribution of magnetic fields.

The eclipse photograph of the corona of July 20, 1963 has been analyzed by Sabattier techniques for coronal isophotes. This study has enabled the derivation of brightness distribution for different position angles to $r=4.2$ solar radii. Intensity gradients over a more restricted range in radius as well as the parameters of ellipticity have been derived.

A considerable amount of effort on the part of several individuals went into the task of fabricating the instrumentation needed for the eclipse expedition to Mexico for the March 1970 eclipse. The experiments planned are direct high resolution photography of the corona and coronal spectroscopy at $30\text{\AA}/\text{mm}$ covering the spectral region from 3300 to 8800\AA .

The sun was photographed in white light on 306 days. H-alpha disc, K-disc and K-prominence spectroheliograms were obtained on 263, 262 and 234 days respectively. H-alpha filtergrams of the disc and with the Lyot monochromatic heliograph

were obtained on 84 days. Observations of the solar chromosphere were made on 278 days covering a total duration of 1309 hours of patrol. 80 flares were observed during the year of which 24 were sub-flares, 37 were classified as belonging to types 1f, 1n and 1b. 18 of importance 2f, 2n and 2b and one of importance 3b. The data provided by routine solar observations have been sent regularly to the world Data Centres.

Observing conditions were more or less as in the previous year. The average definition of the sun's image was 3 on a scale of 5. The North Dome recorded 6 days of seeing 5, 68 days of seeing 4 and 156 days of seeing 3.

The mean equatorial distance of northern hemisphere spot groups was $13^{\circ}.7$ and of the southern hemisphere spot groups $15^{\circ}.2$ as against $15^{\circ}.9$ and $17^{\circ}.5$ respectively in 1968. Details of the spot observations are given in the following table:—

SOLAR DATA 1969

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total mean.
No. of spot N groups	15	18	19	15	23	11	13	15	13	12	15	12	181
S groups	6	11	11	8	14	10	7	11	17	12	9	17	133
Mean daily no. of spot groups	5.5	6.5	7.3	6.2	7.7	5.0	5.6	4.6	5.6	5.4	5.0	6.5	5.9
Kodaikanal daily relative sunspot number	101.9	134.3	146.3	125.8	130.8	102.5	103.1	91.4	98.0	119.3	111.3	124.0	115.7

The mean daily areas and numbers of Calcium Prominences at the limb as obtained from Kodaikanal records are as follows:

1969	Area (Sq. minutes)					Numbers				
	N	S	E	W	Total	N	S	E	W	Total
January- June	3.90	3.32	3.58	3.64	7.22	6.21	5.45	5.74	5.92	11.66
July- December	2.92	2.98	3.07	2.83	5.90	6.75	5.83	6.32	6.26	12.58
Whole year (Wei- ghted mean)	3.57	3.00	3.40	3.37	6.77	6.40	5.58	5.94	6.04	11.98

Compared to the previous year, there was no appreciable variation in activity of numbers, whereas the areas show a decrease of 7%. The distribution of areas in five degree ranges of latitude in the Northern hemisphere shows a peak of activity in the belt 20°-25°. In the Southern hemisphere, the maximum is between 35°-40°.

The mean daily areas and numbers of hydrogen absorption marking on the disc as obtained from Kodaikanal records are as follows:

1969	H-alpha dark marking (areas in millionths of the sun's visible hemisphere uncorrected for foreshortening)					Numbers				
	N	S	E	W	Total	N	S	E	W	Total
January- June	2704	2481	2578	2607	5185	23.16	23.72	23.46	23.42	46.88
July- December	2964	2508	2875	2597	5472	22.53	21.77	23.47	20.83	44.30
Whole Weighted year mean)	2801	2490	2687	2604	5291	22.93	22.99	23.46	22.46	45.92

Compared to the previous year, there was a decrease of activity, the decrease being 12.2% in the case of areas and 9% in the case of numbers. The predominance of activity was in the latitude belt 20°-25° in the Northern hemisphere and in the latitude belt 30°-35° in the Southern hemisphere.

The exchange of spectroheliograms with foreign observatories was continued. For the period July 1968 to June 1969, 34 H-alpha discs, 42 each of K-disc and K-prominence spectroheliograms were received from the Meudon Observatory. One H-alpha disc and 119 K_s spectroheliograms for certain days for the period 1968-69 were sent to the Meudon Observatory.

STELLAR PHYSICS

Spectra of the members of the Scorpio Centaurus association are being obtained at 45°A/mm primarily for the study of rotational velocities. Over 58 members have two spectra each. The plates constitute in addition a source of homogenous information in line intensities of the higher members of the Balmer series and of the neutral helium lines of a genetically related group of young stars in our galaxy.

Spectra of δ Orionis have been obtained and measured for radial velocity to determine the elements and the axial motion. Spectra of the WR spectroscopic binary γ_2 Vel continue to be taken.

The 40-inch Zeiss telescope was received from Germany in March 1969 and is now stored at the field station at Kavalur. The construction of the tower for housing the telescope is in progress.

Spectroscopic analysis of Nova Delphini and Nova Vulpeculae were continued. The microphotometer traces obtained have been reduced to intensity for a study of line profiles at different phases of the nova development. Several striking changes have been noticed.

Eclipsing variables continue to demand a fair share of our observational effort. Photoelectric observations of R Canis Majoris, FT Orionis, Delta Librae and RS Canum Venaticorum have been obtained at Kavalur.

Radio Astronomy

A phase switching interferometer at a frequency of 25 MHz is in operation. The antenna system of the interferometer consists of two arrays one with 72 full wave dipoles and the other with 36 full wave dipoles. The interferometer is being used for studies of occultation of radio sources by the solar corona, ionospheric and interplanetary scintillations and time variations of radio sources.

A multichannel receiving system for recording solar and Jupiter radio bursts with a time resolution of the order of 10 milliseconds is in operation. The three channels are centred around 25.000, 24.800 and 24.600 MHz. A polarimeter capable of receiving R.H. and L.H. circular components on a 10 millisecond time scale at 25 MHz is under construction. The multichannel solar radiometer was operated during periods of enhanced solar emission and a large number of storm bursts were recorded. It is found that the duration of the bursts ranges from less than 1/2 second to several seconds. The band width of the bursts was found to be less than 100 KHz in some cases. Two new types of bursts were recorded. It is also found that the enhanced radiation sometimes exhibits distinct periodicities with periods of the order of 4 to 8 seconds.

The design of an interferometer for medium resolution studies of the Sun at 300 MHz was completed. The construction of the instrument is in progress.

The 3000 MHz radiometer has been in regular operation for solar patrol on a tracking 2 metre paraboloid. The recording of sporadic radio emission from Jupiter at 22.2 MHz has been continued whenever possible. Regular recordings of solar noise flux on frequencies 50, 100 and 220 MHz were continued.

An investigation of the homologous characteristics of solar microwave bursts and associated flares was completed. The results indicate that the homologous bursts are associated with homologous optical flares and vice versa.

Solar-Terrestrial relationships

The main theme of the investigation in Solar Terrestrial Physics has been the estimation of the XUV spectra of the sun, during and outside flares, from the measured parameters of the

ionosphere. Aided by the recently acquired knowledge about the nature of the solar ionising radiation from the various space probes more exact formulations of the continuity equations of the ionisation balance in the upper strata of the terrestrial atmosphere, have been possible. Combining these with the precise measurements of the physical and chemical properties of the ionosphere recently obtained from rocket studies, it has been possible to estimate XUV fluxes from the sun during several solar events.

The correspondence between the solar XUV fluxes thus determined and other visible emission features of the sun was also investigated. The relative quietness of the sun during the IQSY was taken advantage of for this purpose. A series of Lyot filtergrams containing a single plage was photometrically analysed, and the intensities correlated to the corresponding ionisation densities at different heights. The result indicates that the ionisation densities at lower ionospheric heights are weakly correlated with H-alpha flux.

The temporal variation of the red oxygen lines at 6300°A and 6364°A was studied from several nights, records obtained at Kodaikanal. The corresponding $N(h)$ profiles derived from a series of ionograms obtained at the same location were also studied alongside. It was seen that maximum correlation between the airglow intensity and the slab electron content occurs at a height of 260-270 km over Kodaikanal, and has much less variability than the virtual heights of ionisation peaks.

Optical Workshop

The construction of the 25 cm under-corrected hyperboloidal secondary for the 61 cm Ritchey-Chretien telescope and the 30 cm hyperboloidal secondary for the 70 cm Cassegrain telescope were completed.

The optical shop has also completed the construction of the principal telescope for eclipse coronal spectroscopy as well as several off-axis elements for the spectrographs.

Miscellaneous Observations

Routine ozone, meteorological, seismological and radiation observations have been carried out as in the previous year. Three long period and three short period seismographs installed under a co-operative arrangement with U.S. Coast and Geodetic Survey are in continuous operation.

General

Dr. M.K.V. Bappu, Director, Kodaikanal observatory attended the 32nd Executive Committee meeting of the International Astronomical Union held at Frascati (near Rome), Italy during September 20-27, 1969 in his capacity as the Vice-President of the I.A.U.

Visitors

Dr. R. Millis of the Lowell Observatory, Dr. J. Kleczek of the Astronomical Institute, Ondrejov observatory, Czechoslovakia and Dr. M. Golay, Director of the observatory of Geneva, Switzerland visited Kodaikanal Observatory.

Publications

1. Bappu, M.K.V Stellar Chromospheres-Presented at the Symposium on Cosmic Rays, Astrophysics, Geophysics and Elementary Particle Physics 1969 held at the University of Delhi-7-11 October, 1969
2. Bappu, M.K.V. and The Solar Corona of July 20, 1963, Kodaikanal Obs. Bull. No. 190
Bhatnagar A
3. Bappu, M.K.V. and Some Characteristics of Solar wind inferred from the study of Sodium Emission from Cometary Nuclei-Solar Physics-vol. 10, No 2
Sivaraman, K.R
4. Bappu, M.K.V. and Comet Ikeya-Seki (1965) and the nature of the interplanetary medium during its apparition. Kodaikanal Obs. Bull. No. 187
Sivaraman K.R.
5. Bhattacharyya, J.C. Height of 6300 A° and 6364 A° Airglow region in Equatorial Ionosphere. Presented at the "Third International Symposium on Equatorial Aeronomy held in Ahmedabad-February 3-10, 1969

6. Bhattacharyya, J.C. and Sundar R.S. Ionospheric Indication of short time solar activity variations. Presented at the Symposium on Electromagnetic Probing of the upper atmosphere, 16-18 July 1969-held at the Institute of Radio Physics and Electronics, Calcutta.
7. Gopala Rao, U.V. Homologous Microwave bursts and associated solar flares-Solar Physics- Vol. 11 No. 1
8. Sastry, Ch. V. Observations on the time structure of solar radio bursts at a wavelength of 12 metres-Solar Physics-Vol. 10, No. 2
9. Sen Roy, N. A class of dual input all pass networks (I.E.E.E. Vol. 57, No. 5)

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