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(Report for the year ending 1967 December 31)

SOLAR PHYSICS

The new photoelectric detector head of the solar magnetograph was completed and put into operation. Several modifications have been incorporated in the new unit thus providing facility for more accurate measurements of solar longitudinal magnetic fields and velocity fields with compensating arrangements for intensity variations and Doppler shifts. Observations with the new unit have been started in the velocity mode, and the quasi-periodic oscillatory velocity fields have been recorded on lines having mean depths of formation at different heights in the solar atmosphere.

A series of K and Hα spectra of a sunspot close to the limb obtained with the Kitt Peak solar telescope have been used to determine the chromospheric heights in an active region. These spectra have been measured, using equidensity contours obtained by the Sabattier effect. The displacements with wavelength of the level of unit optical depth in the chromosphere over the active region have been obtained. The level in Hα is found to be very much lower than in the K-line of Ca^+. At the K-line centre, unit tangential optical depth in the umbra, umbra–penumbra interface and penumbra are 1310, 1610 and 2330 km respectively. The corresponding value for the umbra in the Hα line centre is 1080 km.

Spectra of few more spots near the limb, in the lines of the Balmer series and metallic lines of lower chromospheric origin have been obtained for study of opacities of the chromosphere over the spots.

In a joint programme with the Sayan Observatory, U.S.S.R., Bappu, Stepanov and Grigorjev obtained transverse and longitudinal magnetic field scans together with K_{232} spectroheliograms covering the early phases of active region formation. Noticeable changes in the background magnetic field are recorded three days prior to the appearance of the sunspot. Magnetic hills of the longitudinal component appear along with bright localized K_{232} emission. The K_{232} emission subsequently spreads along the boundary of one or two adjacent supergranules and at the time of spot formation occupies the whole super-granular cell. Transverse fields of 100–150 G form closed regions in the area of the longitudinal component hills, in the very early phases of the region. These fields stretch and link up the two areas later, at

which time the peak transverse fields with values near 250 G coincide with the zero line of the longitudinal field. When subsequently the spots appear in the new region, the transverse fields are located about the hills of the longitudinal field. The total field vectors just prior to sunspot formation are pressed to the surface. These are inclined about 45° to the surface after the spot appears. These indicate that the magnetic field of a new region emerges from the subphotospheric layers and the super-granule is only instrumental in bringing out these magnetic fields into the outer layers of the solar atmosphere.

Magnetic field measures were obtained on selected sunspots photographically on 20 occasions during the year.

The Sun was photographed in white light on 310 days. Hα-disk, K-disk and K-prominence spectroheliograms were secured on 259, 282 and 252 days respectively. Hα filtergrams of the disk and prominences with the Lyot heliograph were obtained on 148 days. Observations of the solar chromosphere with the spectrohelioscope were made on 290 days covering a total duration of 1169 h of patrol. A total of 59 flares were observed during the year of which 16 were sub-flares, 34 were classified as belonging to types 1f, 1n and 1b, 7 of importance 2f, 2n and 2b, and 2 of importance 3n and 3b. 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 a scale of 5. The north dome recorded five days of seeing 5, 94 days of seeing 4 and 139 days of seeing 3.

There has been a considerable increase in sunspot activity during the year. The mean equatorial distance of northern hemisphere spot groups was 18°·3 and of the southern hemisphere spot groups 21°·1 as against 22°·5 and 18°·6 respectively in 1966. Details of the spot observations are given in Table I.

STELLAR PHYSICS

Photographic, photoelectric and spectroscopic observations were made of Nova Delphini 1967 from 1967 September onwards. The spectra were obtained with the Bhavnagar Cassegrain spectrograph with dispersions of 46 Å mm^{-1} in the blue and 92 Å mm^{-1} in the red. During 1967 September the mean velocity of expansion of ejected shells was 255 km s^{-1}. After the outburst on 1967 December 14 the spectrum of the Nova had dominant emission lines with violet shifted double absorption lines. The secondary absorption system of Fe II lines gave a mean velocity of 736 km s^{-1}. Considerable changes were seen from day to day in the line profiles of the emission and absorption lines.

TABLE I

Solar data 1967

		Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total mean
No. of spot groups	N	20	14	17	20	10	11	15	17	17	19	15	17	192
	S	8	9	8	11	13	7	10	10	10	9	9	18	122
Mean daily No. of spot groups		5·6	5·7	4·9	5·6	5·0	4·2	5·6	5·9	5·5	6·9	6·2	7·4	5·7
Kodaikanal daily relative sunspot number		116·9	107·6	137·0	106·7	122·3	82·6	108·8	122·0	96·9	117·4	113·5	150·5	115·2

Independent photoelectric observations made at Kodaikanal confirmed the second outburst around 1967 August 26 and the magnitude of Nova Delphini continued to be around 4·7 until 1967 November 18. A brightening of 0·3 magnitude was recorded on 1967 November 23.

Photoelectric observations of ρ Puppis were obtained with B, V and narrow-band filters centred around 3890, 4290, 4737 and 5890 Å for the study of colour temperature variations with phase.

Photoelectric observations of the eclipsing binary V Pup were obtained with B, V filters for the study of its light curve. Observations were also made on several nights of the eclipsing systems R CMa, U Ori and β Aur.

A series of 127 spectrograms of the Wolf-Rayet binary HD 68273 obtained at Kodaikanal during 1965 and 1966 have been used for a study of radial velocities of the emission and absorption lines. The period is found to be 78·5 days. The spectral type of the O component is O 7·5 as determined from a single high-dispersion Mount Stromlo coudé spectrogram. The velocity curves of the Wolf-Rayet component are determined for He II 4686, the C III complex at 4652 Å and C IV 4441. The velocity curve for the O component is from measures of the absorption line H5. Arguments are presented to show that the velocity curve of C III 4652 is the best suited for the study of masses of the components. The eccentricity of the orbit is 0·17. The gamma-axis for He II 4686 is red-shifted with respect to that of H5 by 82 km s^{-1}. The values of $m_0 \sin^3 i$ and $m_w \sin^3 i$ are 46·3 and 13·0 solar masses respectively. The inclination of the orbit is likely to be such that the system exhibits eclipses. The W component seems to be the most massive yet known among the very small group of Wolf-Rayet stars.

Low-dispersion spectra (75 Å mm^{-1} at 4300 Å) of HD 193576 have been utilized for radial velocity measures as well as line-profile determinations of some of the emission lines. Using such measures for He II 4686, the elements derived are γ-axis $= +16{\cdot}2$ km s^{-1}, $K = 282{\cdot}8$ km s^{-1}, $e = 0{\cdot}11$, $\varpi = 163°$. The velocity measures of N IV 4058 are combined with earlier measures of Munch to yield the following values: γ-axis (N IV 4058) $= -41{\cdot}5$ km s^{-1}, $K = 302{\cdot}6$ km s^{-1}, $e = 0{\cdot}09$, $\varpi = 130°$, $T_0 = 0{\cdot}26$, $T = 0{\cdot}62$. The velocity measures of the absorption lines 4340 Å and 4100 Å that originate from the O component show much scatter. A combination of the K values of N IV 4058 and Hδ yield masses of the O and W stars as 23·3 and 8·2 solar masses respectively. If 4058 Å is used with the K value derived by Munch from measures of the higher members of the Balmer series, these are 25·0 and 9·9 solar masses respectively.

A few Mount Wilson coudé spectrograms (10 Å mm^{-1}) of this star were obtained at primary and secondary minima and outside eclipse. The emission line N IV 3483 shows a violet absorption edge at primary

minimum. Profiles of H9, H11 and H13 show clearly the increase in width at primary minimum caused by electron scattering. The intensities of the hydrogen lines are also found to increase slightly at this phase.

Radial velocities and line profiles have been studied of the three Wolf-Rayet binaries HD 193928, HD 186943 and HD 211853.

A new orbit for HD 193928 has been determined from radial velocity measures of He II 4686. The orbital elements are as follows: γ-axis = +60 km s^{-1}, K = 147 km s^{-1}, e = 0·12, ϖ = 51°, $f(m)$ = 4·62 solar masses. The N IV 4058 velocities can be represented by the He II 4686 velocity curve displaced in phase by 0·1 period. A displacement of 185 km s^{-1} in the gamma-axis suffices to fit the 4686 Å curve onto the N V 4603 velocities. Line profile variations with phase of the emission lines are described. This system is likely to have an orbital inclination that will enable the detection of eclipses.

A revised period of 9·5594 days is derived for HD 186943. Orbital elements are derived using velocity curves He II 4686, N V 4603 and N IV 4058. The orbital elements derived from He II 4686 are as follows: γ-axis = +107 km s^{-1}, K = 212 km s^{-1}, e = 0·04, ϖ = 151°, γ (N IV 4058) = +70 km s^{-1}, γ (N V 4603) = +30 km s^{-1}.

Preliminary elements have been derived for HD 211853 from velocity curves of He II 4686, N V 4603 and N IV 4058. These are as follows: γ (He II 4686) = +15 km s^{-1}, γ (N V 4603) = +35·0 km s^{-1}, γ (N IV 4058) = −120 km s^{-1}, e (He II 4686) = 0·12, K (He II 4686) = 220 km s^{-1}, $f(m)$ (He II 4686) = 7·25.

RADIO ASTRONOMY

Stanford radio spectroheliograms (9·1 cm λ) were analysed to study the directivity of solar microwave bright regions near sunspot minimum period. The 3000 MHz radiometer has been in regular operation for solar patrol on a tracking 2-m 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 a frequency of 100 MHz were continued.

SOLAR-TERRESTRIAL RELATIONSHIPS

Ionospheric F-region vertical drift velocity over Kodaikanal just after sudden commencement of magnetic storms have been studied with particular reference to the storms that followed proton flare events of 1966 July 7 and 1966 September 2. A 60-h period following the storm commencement has been taken for the analysis. Assuming the conductivity from the standard model atmosphere, the electromagnetic drift velocities are calculated using Poynting's vector. It is found that during the main phase of the storm, the velocity is of the order of a

few metres per second and is directed downwards. This value is used in the calculation of the variation of electron density due to *Dst*.

From the variation of the rate of Faraday fading of Explorer 22 signals recorded at Kodaikanal, estimates of the size distribution of ionospheric irregularities near the magnetic equator have been made.

Continuous recordings of H, D and Z elements of the Earth's magnetic field with Watson and Lacour magnetographs and Askania field balances have been continued. Absolute values of H, D and Z have been determined every week with a set of Q.H.M. and B.M.Z. instruments. During the year 20 geomagnetic storms including 16 of the sudden commencement type have been recorded at Kodaikanal with ranges in horizontal force between 159 γ and 599 γ.

Regular vertical incidence soundings of the ionosphere and registration of short-wave field strengths have been continued. Observations of Faraday fading of 40 and 41 MHz transmission from the beacon satellite Explorer 22 have been made regularly.

OPTICAL SHOP

A 61-cm aperture wide-angle reflector telescope based on the Ritchey–Chrétien principle was designed. The construction of the primary mirror of 61-cm aperture ($f/3{\cdot}5$) for this telescope was completed. The secondary of 25-cm aperture is under construction. Grinding and polishing of a 50-cm aperture spherical mirror ($f/1{\cdot}3$) has been completed. The figuring of this mirror is under progress.

Grinding, polishing and figuring of a 30-cm, $f/3{\cdot}5$ primary mirror for a Cassegrain photometric telescope have been completed.

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