GREENWICH

PHOTO-HELIOGRAPHIC

RESULTS.

1907, 1908.

RESULTS OF MEASURES

MADE AT THE

ROYAL OBSERVATORY, GREENWICH,

UNDER THE DIRECTION OF

SIR W. H. M. CHRISTIE, K.C.B., M.A., D.Sc., F.R.S.
ASTRONOMER ROYAL,

OF

PHOTOGRAPHS OF THE SUN

TAKEN AT

GREENWICH, IN INDIA, AND IN MAURITIUS,

IN THE YEAR

1907.

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ERRATA.

GREENWICH PHOTO-HELIOGRAPHIC RESULTS, 1907.

Measures of Positions and Areas of Sun Spots and Faculæ, 1907.

Page.	Column.	Line.	
5	1	41	Area of Umbra, *for* 58, *read* 28.
		42	Area of Umbra, *for* 13, *read* 58.
		43	Area of Umbra, *for* 28, *read* 13.
	Footnote.		Group 6076, *for* January 9, *read* January 8.
8	Footnote.		Group 6089, *for* January 16–18, *read* January 16–19.
10	Footnote.		Group 6096, *for* January 22–27, *read* January 22–31, and *insert*, The Group is not seen on January 28, 29, and 30.
12	Footnote.		*Insert* January 30. There is an uncertainty in the time of this photograph, and therefore in the longitudes of the spots and faculæ.
15	Footnote.		Group 6107, *for* February 5–16, *read* February 5–17.
20	Footnote.		Group 6113, *for* February 13–24, *read* February 13–23.
22	Footnote.		Group 6117, *for* February 18, *read* February 17.
28	1	36	Group 6134, Distance from Centre, 0·728, *dele* this line.
		44	Group 6134*, *dele* No. of Group, 6134*; Area of Umbra, 0; Area of Whole Spot, 5; and letter *n* to Faculæ.
28	2	5	Total Area of Whole Spots, *for* 1983, *read* 1972.
		15	No. of Group, *for* 6131*, *read* 6131.
43	2	14	No. of Group, *for* 6184, *read* 6185.
45	Footnote.		Group 6188, *for* May 14–17, *read* May 14–19, and *insert*, The Group is not seen on May 18.
49	Footnote.		Group 6204, *for* not seen on January 11, *read* not seen on June 11, and *insert*, Return of Group 6194.
55	Footnote.		Group 6215, *for* July 11–22, *read* July 11–23.
	Footnote.		Group 6216, *for* July 12–22, *read* July 11–23.
57	2	25	No. of Group, *for* 6217, *read* 6215.
57	Footnote.		Group 6220, *for* accompanying, *read* accompany.
	Footnote.		Group 6222, *for* July 23, *read* July 22.
58	Footnote.		Group 6226, *for* August 7, *read* August 8.
62	1	13	No. of Group, *for* 6237, *read* 6233‡.
		35 36	} No. of Group, *for* 6237, *read* 6233‡.
	2	3	No. of Group, *for* 6237, *read* 6233‡.
	Footnote.		*Insert* Group 6233‡. August 16–18. Some small unstable spots, *n* of Group 6233.

66	Footnote.	Group 6249, *insert* Return of Group 6234.
67	Footnote.	Group 6255, *insert* Return of Group 6236.
69	Footnote.	Group 6260, *insert* Return of Group 6244.
	Footnote.	Group 6262, *for* September 18–21, *read* September 18–23, and *insert*, The Group is not seen on September 22.
70	Footnote.	Group 6266, *for* not seen on September 30, *read* not seen on September 29 and 30.
	Footnote.	Group 6267, *for* September 26, *read* September 25.
75	Footnote.	Group 6283, *for* Return of Group 6265, *read* Return of Group 6259.
76	Footnote.	Group 6284, *for* and with it the return of Group 6265, *read* Return of Group 6265.
83	Footnote.	Group 6300, *insert* Return of Group 6286.
88	Footnote.	Group 6314, *insert* Revival after two days of Group 6209.
90	Footnote.	Group 6318, *insert* With Group 6319, the return of Group 6300.
	Footnote.	Group 6319, *for* Return of Group 6300, *read* With Group 6318, the return of Group 6300.
91	Footnote.	Group 6321, *for* Return of Group 6301, *read* Return of Groups 6301 and 6306.
93	Footnote.	Group 6324, *insert* Return or revival of Group 6310.
	Footnote.	*Insert* Group 6321*. December 16. Some small spots far *n* of Group 6321.
96	Footnote.	Group 6324†, *insert* A revival of Group 6324*.
97	Footnote.	*Insert* Group 6334, 1907 December 31—1908 January 1. Some very small spots.

LEDGERS OF SUN SPOTS, 1907.

Page.	Group.		
120	6204	Head-note.	*Insert* Return of Group 6194.
127	6252	Head-note.	*For* it consist, *read* it consists.
	6249	Head-note.	*Insert* Return of Group 6234.
128	6255	Head-note.	*Insert* Return of Group 6236.
129	6260	Head-note.	*Insert* Return of Group 6244.
133	6283	Head-note.	*For* Return of Group 6265, *read* Return of Group 6259.
	6284	Head-note.	*Insert* Return of Group 6265.
136	6300	Head-note.	*Insert* Return of Group 6286.
139	6324	Head-note.	*Insert* Return or revival of Group 6310.

GREENWICH PHOTO-HELIOGRAPHIC RESULTS, 1907.

INTRODUCTION.

§ 1. *Measures of Positions and Areas of Sun Spots and Faculæ on Photographs taken at the Royal Observatory, Greenwich, at Dehra Dûn and at the Kodaikánal Observatory in India, and at the Royal Alfred Observatory, Mauritius, in the year* 1907 ; *with the deduced Heliographic Longitudes and Latitudes.*

The photographs from which these measures were made were taken either at Greenwich; at Dehra Dûn, North-West Provinces, India; at the Kodaikánal Observatory, Southern India; or at the Royal Alfred Observatory, Mauritius.

The photographs of the Greenwich series were taken either with the Thompson or with the Dallmeyer Photoheliograph. The Thompson Photoheliograph, which was in regular use for the greater part of the year, is a photographic refractor of 9 inches aperture, presented to the Royal Observatory by Sir Henry Thompson, which has been fitted with an enlarging doublet by Ross, and with a camera and shutter for rapid exposure so as to take photographs of the Sun on a scale of about 7·5 inches to the solar diameter. The Dallmeyer,—which was substituted for the Thompson for a few days in 1907 November, when the equatorial carrying the latter was being repainted,—is an instrument used in the Transit of Venus expedition to New Zealand, which, as now adapted, gives a solar image of nearly 8 inches diameter on the photographic plate.

The photographs have been taken throughout the year on gelatine dry plates, "Lantern" plates supplied by R. W. Thomas & Co. being used, with hydroquinone development.

The photographs from Dehra Dûn, which have been forwarded by the Solar Physics Committee to fill the gaps in the Greenwich series, were taken under the superintendence of the Deputy Surveyor-General, Trigonometrical Survey of India;

the Kodaikánal photographs were taken under the superintendence of Professor C. Michie Smith, Director of that Observatory; and the Mauritius photographs were taken under the superintendence of Mr. T. F. Claxton, Director of the Royal Alfred Observatory, Mauritius. At each observatory the instrument employed was a Dallmeyer Photoheliograph giving an image of the Sun about 8 inches in diameter. The plates and development used have been much the same at each of the four collaborating observatories.

Photographs of the Sun were available for measurement upon each day in 1907. For 60 of these days photographs taken at the observatory at Dehra Dûn, India, were measured and reduced, but during the preparation of the copy for press of the Ledger of Spot-Groups for 1906, it was found that the latitudes of spot-groups, as determined from the Dehra Dûn photographs, showed considerable discordances as compared with each other and with the latitudes derived from the Greenwich and Kodaikánal photographs. These discordances were found to be due to a disturbance of the adjustment of the Dehra Dûn photoheliograph. So far as possible, therefore, photographs taken at Kodaikánal or Mauritius were substituted for those taken at Dehra Dûn, but for 6 days there were no photographs available except those taken at Dehra Dûn. The photographs finally selected for measurement were supplied by the different observatories as under :—

Greenwich	183
Dehra Dûn	6
Kodaikánal	78
Mauritius	98
Total	365

The *first* column on each page contains the Greenwich civil time at which each photograph was taken, expressed by the day of the year and decimals of a day, reckoning from Greenwich mean midnight January 1d. 0h., and also by the day of the month (civil reckoning), which latter is placed opposite the total area of Spots and Faculæ for the day. The photographs taken at Greenwich are distinguished by the letter G, those taken at Dehra Dûn, in India, by the letter D, those taken at Kodaikánal Observatory, India, by the letter K, and those taken in Mauritius by the letter M.

The *second* column contains the initials of the two persons measuring the photograph; the initial on the left being that of the person who measured the photograph on the left of the centre of the measuring instrument, and that on the right being that of the person who measured on the right of the centre.

The following are the signatures of those persons who measured the photographs for the year 1907 :—

E. W. Maunder	M	C. F. Lait	CL
R. Fowler	RF	F. A. Saville	FS
A. H. Smith	AS		

The *third* column gives the No. of the group, and the letter for the spot. The groups are numbered in order of their appearance.

The *next two* columns give the distance from the centre of the Sun in terms of the Sun's radius, and the position-angle from the Sun's axis, reckoned from the Sun's north pole in the direction n, f, s, p, both results being corrected for the effects of astronomical refraction.

The measures of the photographs were made with a large position-micrometer specially constructed by Messrs. Troughton and Simms for the measurement of photographs of the Sun up to 12 inches in diameter. In this micrometer the photograph is held with its film-side uppermost on three pillars fixed on a circular plate, which can be turned through a small angle, about a pivot in its circumference, by means of a screw and antagonistic spring acting at the opposite extremity of the diameter. The pivot of this plate is mounted on the circumference of another circular plate, which can be turned by screw-action about a pivot in its circumference, 90° distant from that of the upper plate, this pivot being mounted on a circular plate with position-circle which rotates about its centre. By this means small movements in two directions at right angles to each other can be readily given, and the photograph can be accurately centred with respect to the position-circle. When this has been done, a positive eyepiece, having at its focus a glass diaphragm ruled with cross-lines into squares, with sides of one-hundredth of an inch (for measurement of areas), is moved along a slide diametrically across the photograph, the diaphragm being nearly in contact with the photographic film, so that parallax is avoided. The distance of a spot or facula from the centre of the Sun is read off by means of a scale and vernier to 1-250th of an inch (corresponding to 0·001 of the Sun's radius for photographs having a solar diameter of 8 inches). The position-angle is read off on a large position-circle which rotates with the photographic plate. The photograph is illuminated by diffused light reflected from white paper placed at an angle of 45° between the photograph and the plate below.

The following is the process of measurement of a photograph :—By means of the screws attached to the circular plates carrying the pillars which hold the photograph, the image of the Sun is centred as accurately as possible by rotation. The position-

circle is then set to the readings 0°, 90°, 180°, and 270° in succession, and the scale readings taken for the two limbs. The scale being so adjusted that its zero coincides with the centre of rotation of the position-circle, the mean of the eight readings for the limb gives the mean radius of the Sun directly.

At the principal focus of the photoheliograph are two cross-spider-lines which serve to determine the zero of position-angles on the photograph.

The zero of position-angles for the Thompson Photoheliograph employed at Greenwich has been determined by the measurement of a plate which has been exposed to the Sun's rays twice, with an interval of about 100 seconds between the two exposures, the instrument being firmly clamped. Two images of the Sun, overlapping each other by about a fifth part of the Sun's diameter, were therefore produced upon the plate, and the exposures having been so given that the line joining the cusps passed approximately through the centre of the plate, the inclination of the wires of the photoheliograph to this line was measured with the position-micrometer, and a small correction for the inclination of the Sun's path was then applied. The following table gives the correction for zero of position for the mean of the two wires as thus determined :—

Thompson Photoheliograph.

Date, Greenwich Civil Time.			Correction for Zero.	Date, Greenwich Civil Time.			Correction for Zero.
		d h	° ′			d h	° ′
1906	October	1. 12	+ 0. 5	1907	August	20. 11	− 0. 3
1907	January	4. 12	− 0. 2			22. 12	− 0. 11
		29. 12	+ 0. 3			25. 12	− 0. 11·5
	March	6. 11	− 0. 11		September	28. 11	− 0. 3
	April	2. 13	− 0. 5		November	28. 12	− 0. 6·5
		17. 12	− 0. 3			28. 12	− 0. 5
	May	8. 12	− 0. 7		December	7. 11	+ 0. 2
	July	29. 13	+ 0. 5			9. 13	+ 0. 3
		31. 12	+ 0. 2	1908	February	12. 11	− 0. 10

A correction of −0°·1 for zero of position has been applied to all photographs taken with the Thompson Photoheliograph throughout the year 1907.

The Thompson Photoheliograph was mounted on the tube of the 26-inch Thompson Photographic refractor throughout the year. It is not fitted with a position-circle, and the position-angle of the wires, which are approximately parallel and perpendicular to the circle of declination, cannot be altered.

The Dallmeyer Photoheliograph was mounted throughout the year on the equatorial

stand belonging to it, which was erected on the terrace roof of the South Wing of the New Physical Observatory.

In the use at Greenwich of the Dallmeyer Photoheliograph the position-circle has usually been set to some convenient reading near that for zero, so that the wires are respectively very nearly parallel and perpendicular to the circle of declination, and a correction for zero of position of the photoheliograph for the mean of the two wires has been applied to the zero of the position-circle of the micrometer. The position-circle was set to the reading 354°·0 throughout 1907.

The zero of the position-circle of the micrometer has been determined from the readings of the position-circle for the four extremities of the two wires. The resulting combined correction is applied to all position-circle readings for spots and faculæ, so as to give true position-angles.

In the use of the photoheliograph in Mauritius the zero of position during the years 1906 and 1907 has been determined in the same way as at Greenwich, by the measurement of a plate which has been exposed to the sun's rays twice, with an interval of about 100 seconds between the two exposures. The following table gives the correction for zero of position for the mean of the two wires :—

Mauritius Photoheliograph.

Date, Greenwich Civil Time.			Correction for Zero.	Date, Greenwich Civil Time.			Correction for Zero.
		d h	° ′			d h	° ′
1906	February	13. 5	− 3.49	1907	January	5. 5	− 4.30
	March	25. 5	− 3.53		February	18. 10	− 5.38
	April	12. 5	− 3.31		March	13. 6	− 5. 9
	May	11. 5	− 3.32		April	20. 6	− 6.17
	June	27. 5	− 4. 6		May	8. 8	− 4.47
	August	16. 5	− 3.19		June	9. 6	− 4.18
		29. 6	− 4.37		July	7. 8	− 6.11
	September	13. 5	− 3.46		October	26. 6	− 5.30
	November	6. 5	− 4. 3		November	18. 8	− 5.17
		26. 5	− 4.33		December	31. 9	− 5. 9
	December	15. 5	− 4.17	1908	January	29. 10	− 5.41

New wires were inserted on 1907 February 18.

As in the year 1906, a correction of −4°·0° for zero of position has been applied to all photographs taken with the Mauritius photoheliograph, up to 1907 February 18, when the new wires were inserted. After that date a correction of −5°·4 has been applied.

The Director of the Kodaikánal Observatory has reported, for each of the photographs that he has supplied, the amount of the correction for zero of position of wires that it is necessary to apply.

In the case of the six photographs taken at Dehra Dûn, for which the error of position of the wires is not known, the measures of the areas have been used, and, for the identification of the spots and faculæ, a correction for zero of position has been estimated from a comparison with the photographs taken on the days immediately preceding and following. The heliographic longitudes and latitudes thus deduced for these six photographs are only approximate and have been placed in brackets.

The uncorrected distance from the Sun's centre for spots and faculæ is read off directly to 1-250th of an inch by means of a scale and vernier, the zero of the scale of the micrometer being adjusted to coincide with the centre of the instrument.

Two sets of measures of the Sun's limb and of spots and faculæ on each photograph have been taken, and the mean of the two sets adopted.

No correction has been applied to the photographs on account of distortion.

The correction for the effect of refraction has been thus found, the Sun's image being assumed to be sensibly an ellipse. The refraction being sensibly $c \tan z$ where $c = \sin 57''{\cdot}5 = \frac{1}{3600}$ nearly, and z is the apparent zenith-distance, we shall have—

$$\frac{\text{Vertical Diameter}}{\text{Horizontal Diameter}} = \frac{1 - c \sec^2 z}{1 - c} = 1 - c \tan^2 z;$$

and thus the effect of refraction will be to diminish any vertical ordinate y by the quantity $c \tan^2 z$. Resolving this along and perpendicular to the radius vector r, and putting v for the position-angle of the vertex, we have for δr and $\delta \theta$, the corrections to radius vector and position-angle for the effect of refraction—

$$\delta r = + c \,.\, \tan^2 z \times r \,.\, \cos^2(\theta - v) = + c \,.\, \tan^2 z \times r \times \frac{1 + \cos 2(\theta - v)}{2},$$

$$\delta \theta = - c \,.\, \tan^2 z \,.\, \sin(\theta - v) \,.\, \cos(\theta - v) = - c \,.\, \tan^2 z \, \frac{\sin 2(\theta - v)}{2}.$$

The quantity δr thus found is the correction, on the supposition that a horizontal diameter of the Sun is taken as the scale. But, as the mean of two diameters at right angles has been used, the scale itself requires the correction $\delta R = + c \,.\, \tan^2 z \times R \times \frac{1}{2}\left\{\frac{1 + \cos 2(\theta_0 - v)}{2} + \frac{1 + \cos 2(\theta_0 + 90^\circ - v)}{2}\right\} = + \frac{1}{2} c R \,.\, \tan^2 z$, where R is the Sun's mean radius and θ_0, $\theta_0 + 90^\circ$ the position-angles of the two diameters measured. Thus the final correction to r becomes—

$$\delta r = + c \,.\, \tan^2 z \times r \times \frac{\cos 2(\theta - v)}{2}.$$

The quantities $c \tan^2 z$, $-\frac{\sin 2(\theta - v)}{2}$, and $\frac{\cos 2(\theta - v)}{2}$ have been tabulated for use as follows, $c \tan^2 z$ being expressed in circular measure and in arc for application to distances and position-angles respectively :—

$c \tan^2 z$.

z.	In Circular Measure.	In Arc.	z.	In Circular Measure.	In Arc.	z.	In Circular Measure.	In Arc.
°		′	°		′	°		′
80	·0089	31	70	·0021	7	60	·0008	3
79	·0073	25	69	·0019	6½	58	·0007	2
78	·0061	21	68	·0017	6	56	·0006	2
77	·0052	18	67	·0015	5½	54	·0005	2
76	·0045	15	66	·0014	5	52	·0005	2
75	·0039	13	65	·0013	4½	50	·0004	1
74	·0034	11½	64	·0012	4	45	·0003	1
73	·0030	10	63	·0011	4	40	·0002	1
72	·0026	9	62	·0010	3	30	·0001	0
71	·0023	8	61	·0009	3			

Factors for Refraction.

$\theta - v$	$\theta - v$	$-\frac{\text{Sin } 2(\theta - v)}{2}$	$\frac{\text{Cos } 2(\theta - v)}{2}$	$\theta - v$	$\theta - v$	$-\frac{\text{Sin } 2(\theta - v)}{2}$	$\frac{\text{Cos } 2(\theta - v)}{2}$
°	°			°	°		
0	180	·00	+ ·50	90	270	·00	− ·50
5	185	− ·09	+ ·49	95	275	+ ·09	− ·49
10	190	− ·17	+ ·47	100	280	+ ·17	− ·47
15	195	− ·25	+ ·43	105	285	+ ·25	− ·43
20	200	− ·32	+ ·38	110	290	+ ·32	− ·38
25	205	− ·38	+ ·32	115	295	+ ·38	− ·32
30	210	− ·43	+ ·25	120	300	+ ·43	− ·25
35	215	− ·47	+ ·17	125	305	+ ·47	− ·17
40	220	− ·49	+ ·09	130	310	+ ·49	− ·09
45	225	− ·50	·00	135	315	+ ·50	·00
50	230	− ·49	− ·09	140	320	+ ·49	+ ·09
55	235	− ·47	− ·17	145	325	+ ·47	+ ·17
60	240	− ·43	− ·25	150	330	+ ·43	+ ·25
65	245	− ·38	− ·32	155	335	+ ·38	+ ·32
70	250	− ·32	− ·38	160	340	+ ·32	+ ·38
75	255	− ·25	− ·43	165	345	+ ·25	+ ·43
80	260	− ·17	− ·47	170	350	+ ·17	+ ·47
85	265	− ·09	− ·49	175	355	+ ·09	+ ·49
90	270	·00	− ·50	180	360	·00	+ ·50

The position-angle of the vertex v is readily taken from a globe.

The distance from centre in terms of the Sun's radius given in the *fourth* column is then readily found by dividing the measured distance r_0, as corrected for refraction,

by the measured mean radius of the Sun, R; and the position-angle from the Sun's axis given in the *fifth* column is obtained by applying to the position-angle (from the N. point) corrected for refraction the position-angle of the Sun's axis derived from the *Auxiliary Tables for determining the Angle of Position of the Sun's Axis, and the Latitude and Longitude of the Earth referred to the Sun's Equator*, by Warren De La Rue, F.R.S. This position-angle of the Sun's axis from the North point is also given (in brackets) in the *fifth* column.

The *sixth* and *seventh* columns give the heliographic longitude and latitude of the spot, which are thus computed.* Let r be the measured distance of a spot from the centre of the Sun's apparent disk, R the measured radius of the Sun on the photograph, (R) the tabular semidiameter of the Sun in arc, and ρ, ρ' the angular distances of a spot from the centre of the apparent disk as viewed from the Sun's centre and from the Earth respectively. Then we have—

$$\rho' = \frac{r}{R}(R); \text{ and } \sin(\rho + \rho') = \frac{r}{R},$$

$$\text{whence } \rho = \sin^{-1}\frac{r}{R} - \rho'.$$

Log. sin ρ and log. cos ρ, as computed from this formula, are given in *Tables for the Reduction of Solar Observations No.* 2, by Warren De La Rue, F.R.S. Then, if D, λ are the heliographic latitudes of the Earth and the spot respectively, referred to the Sun's equator, and l the heliographic longitude of the spot from the solar meridian passing through the centre of the disk, longitudes west of the centre being reckoned as positive, and χ the position-angle from the Sun's axis, we have by the ordinary equations of spherical trigonometry—

$$\sin\lambda = \cos\rho \sin D + \sin\rho \cos D \cos\chi$$
$$\sin l = -\sin\chi \sin\rho \sec\lambda.$$

The position-angle χ is found from the position-angle from the North Point by subtracting from it algebraically, P, the position-angle of the N end of the Sun's axis, measured eastward from the North Point of the disk. The heliographic longitude of the spot is found from l, its heliographic longitude from the Central Meridian, by adding l algebraically to L, the heliographic longitude of the centre of the disk. The three quantities P, D, and L for the time of the exposure of each photograph are derived from the Ephemeris for Physical Observations of the Sun given on p. 18 of

* "Researches on Solar Physics: Heliographical Positions and Areas of Sun Spots observed with the Kew Photoheliograph during the years 1862 and 1863," by W. De La Rue, B. Stewart, and B. Loewy. *Phil. Trans.*, 1869.

the *Appendix* to the *Nautical Almanac* for 1907, and are printed (in brackets) in the *fifth*, *sixth*, and *seventh* columns respectively. D, the heliographic latitude of the Earth, is of course the same as the latitude of the centre of the Sun's disk.

The inclination of the Sun's axis to the ecliptic is assumed to be 82° 45′, the longitude of the ascending node for 1907·0 to be 74° 27′·7, and the period of the Sun's sidereal rotation to be 25·38 days; the meridian which passed through the ascending node 1854 January 1, Greenwich Mean Noon, being taken as the zero meridian.

The measures of areas given in the *last three* columns were made with a glass diaphragm ruled into squares, with sides of one-hundredth of an inch, and placed as nearly as possible in contact with the photographic film. The integral number of squares and parts of a square contained in the area of a spot or facula was estimated by the observer, two independent sets of measures being made by two observers. The mean of the two sets of measures has been taken for each photograph. The factor for converting the areas, as measured in ten-thousandths of a square inch, into millionths of the Sun's visible hemisphere, allowing for the effect of foreshortening, has been inferred by means of a table of double entry, giving the equivalent of one square for different values of the Sun's radius, and for different distances of the spot or facula from the Sun's centre as measured by means of the position-micrometer.

The individual spots in a group have in many cases not been measured separately, but combined into a cluster of two or three small spots close together, the position of the centre of gravity and the aggregate area of the cluster being given.

§ 2. *Ledgers of Areas and Heliographic Positions of Groups of Sun Spots deduced from the measurement of the Solar photographs for each day in the year* 1907.

In these ledgers the daily results for each group are collected together from the measures of the individual spots and given in a condensed form. The first column gives, for each day on which the group was observed, the Greenwich civil time at which each photograph was taken, expressed by the day of the month (civil reckoning) and the decimals of a day reckoning from Greenwich mean midnight. The second column indicates by the initial letter of the observatory, the place where the photograph was taken; the letters G, D, K, and M, standing for Greenwich, Dehra Dûn, Kodaikánal, and Mauritius respectively. The third and fourth columns give the sums, for each day, of the projected areas of all the umbræ and whole spots comprised in the group, the projected area being the area as it is measured upon the photograph,

uncorrected for foreshortening, and expressed in millionths of the Sun's apparent disk. The fifth and sixth columns give the sums for each day of the areas of all the umbræ and whole spots comprised in the group, corrected for foreshortening, and expressed in millionths of the Sun's visible hemisphere. The seventh and eighth columns give the mean longitude and latitude of the group, found by multiplying the longitude and latitude of each separately measured component of the group by its area, and dividing the sum of the products by the sum of the areas. The last column gives the mean longitude of the group from the central meridian, and is found by subtracting the longitude of the centre of the disk from the mean longitude of the group. At the foot of these daily results for each group are given the mean areas of umbræ and whole spots and the mean longitude and latitude for the period of observation.

§ 3. *Catalogue of Recurrent Groups of Sun Spots compiled from the Ledgers of Groups of Sun Spots for the year* 1907.

This catalogue is in continuation of the Catalogue of Recurrent Groups of Sun Spots for the Years 1874 to 1906, published as an *Appendix* to the *Greenwich Observations*, 1907; and, therefore the reference numbers contained in the first column, run on from those given therein. The number of the spot group is given in the second column and the third column gives the synodic Rotation of the Sun, when the spot group crossed the central meridian, the Rotations being numbered as on pp. 154 and 155. The third and fourth columns give, for each group, the Date of the photograph upon which the group was first seen, and the Heliographic Longitude from the Central Meridian of the group as measured on that photograph; the sixth and seventh columns, in like manner, give the Date of the photograph on which the group was last seen, with its Longitude from the Central Meridian then; whilst the eighth column gives the number of days for which photographs are available on which the group was measured. The four columns next following give respectively the Mean Daily Area as corrected for fore-shortening, for the Umbræ and for the Whole Spots of the group, together with its Mean Heliographic Longitude and Latitude, and are derived directly from the Ledger of Spot Groups; and the last column supplies a brief description of the group.

The method of forming the Catalogue has been this:—If any spot group when first seen was 60° or more to the east of the Central Meridian—the detail given in the fifth column,—then the Spot Ledgers, and, if necessary, the Daily Heliographic Results also, were searched some fifteen or sixteen days earlier, to ascertain whether a spot group of similar heliographic longitude and latitude was then near the west limb of

the Sun. Similarly, if any spot group when last seen was 60° or more to the west of the Central Meridian—the detail given in the seventh column,—then the Spot Ledgers, and, if necessary, the Daily Heliographic Results also, were searched some fifteen or sixteen days later, to ascertain whether a spot group of similar heliographic longitude and latitude was then near the east limb of the Sun. Both the search forward and the search backward have been made in the case of every spot group that was observed close to both the east and west limbs, in order that no possible case of identity might be overlooked. When there appeared to be a case of probable identity between spot groups observed in two consecutive rotations of the Sun, the character of the second group has been carefully compared with that of the first in each of the three elements —area, longitude, and latitude. In cases where the weight of evidence appeared to render probable the continued existence of the spot, it has been numbered in the catalogue and where there has been some element of uncertainty, a note has been added. If, on the other hand, the weight of evidence appeared to go in the other direction, but was not quite decisive, the series has been printed in the catalogue but a separate number has not been given it. It has been distinguished by the number of the preceding series, placed in brackets and marked with an asterisk. In cases where a well-defined series has been recorded, there have sometimes been included in brackets spot groups undoubtedly belonging to the same general disturbance, but for which the evidence of continuity of action was not sufficient. All cases have been excluded from the catalogue wherein there has been a clear unmistakable breach of continuity of action.

§ 4. *Total Areas of Sun Spots and Faculæ for each day, and Mean Areas and Mean Heliographic Latitude of Sun Spots and Faculæ for each Rotation of the Sun, and for the year* 1907.

This section requires no further explanation.

W. H. M. CHRISTIE.

Royal Observatory, Greenwich,
1910 *June* 18.

ROYAL OBSERVATORY, GREENWICH.

MEASURES OF POSITIONS AND AREAS

OF

SUN SPOTS AND FACULÆ

ON

PHOTOGRAPHS

TAKEN WITH THE

PHOTOHELIOGRAPHS

AT GREENWICH, IN INDIA, AND IN MAURITIUS,

WITH THE DEDUCED

HELIOGRAPHIC LONGITUDES AND LATITUDES.

1907.

Measures of Positions and Areas of Sun Spots and Faculæ on Photographs taken at the Royal Observatory, Greenwich, at Kodaikánal and at Dehra Dûn in India, and at the Royal Alfred Observatory, Mauritius, in the Year 1907.

Note.—The Greenwich Civil Time at which the Photograph was taken is expressed by the Day of the Year and decimals of a day, reckoning from Midnight, January 1d 0h. For convenience of reference, the Month and Day of the Month (Civil Reckoning) are added.

The letter G. signifies that the photograph was taken at Greenwich; the letter K. that it was taken at Kodaikánal; the letter D. that it was taken at Dehra Dûn; the letter M. that it was taken in Mauritius; the time given is Greenwich Civil Time.

The position-angles are reckoned from the North Pole of the Sun's Axis in the direction N., E., S., W., N. Counter clockwise

The Groups of Spots are numbered in the order of their appearance. When there is no number in the third column, it is to be understood that there is a Facula unaccompanied by a Spot. The positions of Faculæ relative to the Spots with which they are associated are indicated by the letters *n*, *s*, *p*, *f*, *c*, denoting respectively north, south, preceding, following, concentric.

The Areas of Spots and Faculæ are expressed in millionths of the Sun's visible Hemisphere.

In the line immediately below the results for each day are given in brackets:—1. The Position Angle of the Sun's Axis (from the North point); 2. The Heliographic Longitude and Latitude of the Centre of the Disc; 3. The total areas for each day of Spots and Faculæ.

Greenwich Civil Time.	Measurers.	No. of Group, and Letter for Spot.	Distance from Centre in terms of Sun's Radius.	Position Angle from Sun's Axis.	Heliographic Longitude.	Heliographic Latitude.	Spots. Area of UMBRA for each Spot (and for Day).	Spots. Area of WHOLE for each Spot (and for Day).	Faculæ. Area for each Group (and for Day).
1907.				°	°	°			
0·135	AS, M		0·973	290·3	217·2	+18·9			316
			0·932	280·4	210·4	+ 8·5			135
			0·824	291·1	195·4	+15·3			331
		6061	0·597	288·8	177·4	+ 8·5	1	12	
		6061	0·576	289·7	175·8	+ 8·6	0	3	
		6061	0·539	290·5	173·2	+ 8·2	0	2	
		6061	0·528	291·1	172·4	+ 8·2	1	11	
		6056	0·289	3·5	141·7	+13·6	0	8	
		6062	0·169	148·0	137·5	−11·3	0	2	
		6062	0·212	141·7	135·0	−12·6	0	3	
		6062	0·217	137·0	134·0	−12·2	0	2	
		6063	0·260	132·7	131·4	−13·1	0	9	
		6063	0·285	132·0	130·1	−14·0	0	2	
		6063	0·283	127·6	129·5	−13·0	0	4	
		6063	0·296	127·9	128·9	−13·5	4	20	
		6063	0·313	125·3	127·5	−13·4	1	6	
K.		6058	0·209	104·7	131·0	− 6·1	2	13	
		6059*a*	0·580	72·7	108·9	+ 7·4	85	526	
		6059	0·570	78·2	108·8	+ 4·1	0	2	
		6059	0·603	77·6	106·6	+ 5·0	0	6	
		6059	0·617	74·7	106·0	+ 6·9	5	25	
		6059	0·624	75·6	105·4	+ 6·5	0	1	
		6059	0·630	73·6	105·3	+ 7·8	0	1	
		6059	0·641	76·1	104·1	+ 6·4	0	1	
		6059	0·645	74·6	104·0	+ 7·4	0	9	
		6059	0·668	77·6	101·9	+ 5·9	0	2	
		6059*b*	0·693	76·0	100·2	+ 7·4	73	541	
		6059	0·708	74·5	99·2	+ 8·6	0	3	
		6065	0·952	70·1	72·8	+17·8	0	10	473*c*
		6066*a*	0·989	80·8	62·0	+ 8·6	13	84	241*np*
			0·831	72·3	88·6	+12·8			89
			0·902	62·7	82·5	+22·8			91
			0·959	102·7	69·1	−13·1			275
Jan. 1				(+2·4)	(142·7)	(− 3·1)	(185)	(1308)	(1951)

Greenwich Civil Time.	Measurers.	No. of Group, and Letter for Spot.	Distance from Centre in terms of Sun's Radius.	Position Angle from Sun's Axis.	Heliographic Longitude.	Heliographic Latitude.	Spots. Area of UMBRA for each Spot (and for Day).	Spots. Area of WHOLE for each Spot (and for Day).	Faculæ. Area for each Group (and for Day).
1907.				°	°	°			
1·418	CL, AS		0·928	289·8	191·6	+17·0			496
			0·871	301·3	180·9	+25·0			259
			0·802	257·5	178·9	−12·0			107
		6061	0·801	283·5	177·7	+ 8·8	11	33	
		6061	0·771	285·1	174·7	+ 9·5	7	15	133*c*
		6061	0·753	284·9	173·2	+ 9·0	0	9	
		6067	0·512	287·4	155·2	+ 6·0	0	11	
		6067	0·499	285·8	154·6	+ 5·0	2	12	
		6067*a*	0·493	291·3	153·4	+ 7·4	11	36	
		6067	0·482	288·3	153·2	+ 5·8	0	8	
		6062	0·248	235·6	137·9	−11·1	1	9	
		6062	0·233	224·4	135·5	−12·7	2	8	
		6062	0·212	213·9	132·8	−13·3	12	69	
		6063	0·200	197·6	129·5	−14·1	0	5	
		6063	0·185	191·6	128·1	−13·6	0	2	
		6063	0·193	186·2	127·1	−14·3	8	29	
		6058	0·133	239·9	132·5	− 7·0	4	32	
M.		6058	0·116	231·2	131·1	− 7·3	0	3	
		6058	0·076	232·3	129·4	− 5·9	1	4	
		6058	0·087	221·5	129·2	− 7·0	2	12	
		6058	0·073	201·9	127·5	− 7·1	2	20	
		6059	0·317	51·5	111·5	+ 8·2	0	5	
		6059*a*	0·340	58·1	109·1	+ 7·3	92	456	
		6059	0·364	64·2	106·7	+ 6·0	3	40	
		6059	0·391	60·8	105·8	+ 8·0	10	55	
		6059	0·388	64·2	105·4	+ 6·7	0	7	
		6059	0·420	65·4	103·4	+ 7·1	0	2	
		6059	0·430	68·6	102·3	+ 6·1	0	31	
		6059	0·460	65·8	100·9	+ 8·0	9	60	
		6059	0·460	67·1	100·7	+ 7·4	0	6	
		6059	0·482	67·3	99·3	+ 7·8	0	3	
		6059	0·465	74·5	99·3	+ 4·3	35	319	
		6065	0·824	67·6	73·6	+16·3	0	29	283*f*
		6065	0·831	69·2	72·4	+15·3	0	5	

Group 6056, 1906 December 27–1907 January 1. A number of spots, most of them very small, in a short irregular stream. The group is not seen on 1906 December 31.

Group 6059, 1906 December 29–1907 January 9. A magnificent stream, chiefly composed of two very large composite spots, *a* and *b*. Of these *a* has become regular in form by January 3, and *b* has broken up, and the group has taken the form of a great circular leader spot, followed by a long straight train of small spots.

Group 6058, 1906 December 30–1907 January 7. A number of small spots in a straggling stream.

Group 6061, 1906 December 31–1907 January 3. A few small unstable spots in a short stream, *sf* Group 6060.

Group 6062, 1906 December 31–1907 January 7. A few small unstable spots, *sp* Group 6058.

Group 6063, 1906 December 31–1907 January 3. A few small unstable spots, *sf* Group 6058 and *f* Group 6062, and forming with the latter group an irregular straggling stream.

Group 6065, 1907 January 1–3. A disturbed area with one or two small unstable spots.

Group 6066, January 1–10. Return of Group 6044. A regular spot, *a*, on January 1. A number of small spots form around *a*, on January 3, and the succeeding days, and *a* has broken up by January 8; the group now appearing as an irregular stream of small unstable spots.

Group 6067, January 2–6. Two small clusters at first, rapidly developing into a very irregular stream, inclined to the equator. The principal spot, *a*, is in the rear of the group, and develops into a large regular spot with double nucleus.