

# RESULTS OF MEASURES

MADE AT THE

## ROYAL OBSERVATORY, GREENWICH

UNDER THE DIRECTION OF

SIR FRANK DYSON, M.A., LL.D., F.R.S.,  
ASTRONOMER ROYAL,

OF

# PHOTOGRAPHS OF THE SUN

TAKEN

## AT GREENWICH, AT THE CAPE, AND IN INDIA

IN THE YEAR

### 1918.

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#### D iv INTRODUCTION TO GREENWICH PHOTO-HELIOGRAPHIC RESULTS, 1918.

The names of those persons who measured the photographs for the year 1918 are as follows :—

Annie S. D. Maunder

H. W. Newton

F. Jeffries

E. Martin

At the principal focus of the Photoheliographs excepting that at Kodaikánal two spider-lines are fixed by which the zero of position-angles on the photographs can be determined. These lines are respectively perpendicular and parallel to the equator in the Photoheliographs at the Cape and at Dehra Dûn, but are inclined to it at an angle of about  $45^\circ$  in that at Greenwich. In the Kodaikánal Photoheliograph there is one wire fixed parallel to the equator.

The zero of position-angles for the Greenwich, Cape, and Kodaikánal Photoheliographs has been determined by the measurement of plates which have been exposed 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 plates, and the exposures having been so given that the line joining the cusps passed approximately through the centre of the plates, 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 tables give the correction for zero of position for the mean of the two wires as thus determined for the Greenwich and Cape Photoheliographs.

The zero-correction used throughout the year 1918 in the reduction of the photographs taken at Greenwich was  $+ 2^\circ.7$ .

The zero-corrections used in the reduction of the photographs taken at the Cape Observatory were as follows :—

Jan. 1 to March 31,  $+ 0^\circ.2$  ; April 1 to Sept. 30,  $+ 0^\circ.25$  ; Oct. 1 to Dec. 31,  $+ 0^\circ.2$ .

INTRODUCTION TO GREENWICH PHOTO-HELIOGRAPHIC RESULTS, 1918. D v

DALLMEYER PHOTOHELIOGRAPH, GREENWICH.

Date. Greenwich Civil Time.		Correction for Zero.	Date. Greenwich Civil Time.		Correction for Zero.
1918 January	d h 21. 11	° ' / + 2 49	1918 July	d h 31. 9	° ' / + 2 36
"	21. 11	+ 2 45	"	31. 9	+ 2 30
March	6. 13	+ 2 58	August	29. 9	+ 2 46
"	6. 13	+ 2 49	"	29. 10	+ 2 39
May	27. 10	+ 2 46	October	4. 11	+ 2 38
"	27. 11	+ 2 46	"	4. 12	+ 2 53
June	3. 9	+ 2 36	November	5. 10	+ 2 30
"	3. 10	+ 2 35	"	16. 11	+ 2 39
July	2. 9	+ 2 32	"	16. 11	+ 2 35
"	2. 9	+ 2 51			

DALLMEYER PHOTOHELIOGRAPH, CAPE OF GOOD HOPE.

Date. Greenwich Civil Time.		Correction for Zero.	Date. Greenwich Civil Time.		Correction for Zero.
1918 January	d h 7. 8	° ' / + 0 6	1918 July	d h 8. 10	° ' / + 0 26
"	22. 10	+ 0 5	"	23. 10	+ 0 12
February	6. 8	+ 0 5	August	7. 11	+ 0 22
March	9. 8	+ 0 22	"	22. 9	+ 0 11
"	24. 9	+ 0 13	September	10. 10	+ 0 4
April	8. 10	+ 0 19	"	25. 8	+ 0 19
"	23. 9	+ 0 21	October	15. 8	+ 0 17
May	29. 10	+ 0 7	November	1. 8	+ 0 12
June	21. 10	+ 0 15	December	3. 8	+ 0 11
			"	17. 10	+ 0 12

The wire frame was removed for cleaning on November 14.

The zero-correction adopted during 1918 for the Kodaikánal photographs was  $+0^{\circ}.1$ .

The adjustment of the wires in the Dehra Dûn Photoheliograph was usually tested by stopping the driving clock immediately after a photograph had been taken and making a second exposure some two minutes after the first, a portion of a second image of the Sun, just intersecting the first, being thus obtained upon the plate.

The zero-correction adopted during 1918 for the Dehra Dûn photographs was  $-0^{\circ}.8$ .

The measures of the photographs were made with a large position-micrometer 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,  $90^{\circ}$  distant from that of the upper plate, this pivot being mounted on a circular plate with a 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 the 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  $45^{\circ}$  between the photograph and the plate below.

All photographs are measured independently by two persons, and the means taken.

In the case of large or complex groups of spots, the positions of the chief components are measured individually, and also for groups so near the east or west limbs of the Sun that the effects of foreshortening are appreciable. In other cases the position of the centre of a group is estimated in the micrometer. In this respect a difference has been made in the practice during years previous to 1916, where in this section components of groups are given separately and combined into groups in the Ledgers.

When required, corrections are applied to the measured distances and position-angles for differential refraction. The formula is given in the *Introduction* for 1909. It is seldom necessary, however, to apply this correction except to a few photographs taken at Greenwich in mid-winter.

The calculations of heliographic longitude and latitude are made by use of the formulæ given in "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. If  $r$  be the measured distance of a spot from the centre of the Sun's apparent disc,  $R$  the measured radius of the Sun on the photograph,  $(R)$  the tabular semi-diameter of the Sun in arc, and  $\rho$ ,  $\rho'$  the angular distances of a spot from the centre of the apparent disc as viewed from the Sun's centre and from the Earth respectively,  $\rho$  is obtained from the equations:—

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

If  $D$  and  $\phi$  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 disc, longitudes west of the centre being reckoned as positive, and  $\alpha$  the position-angle from the Sun's axis,

$$\sin \phi = \cos \rho \sin D + \sin \rho \cos D \cos \alpha$$

$$\sin l = -\sin \alpha \sin \rho \sec \phi.$$

The position-angle  $\alpha$  is found from the position-angle from the North Point by subtracting  $P$ , the position-angle of the N end of the Sun's axis, measured eastward from the North Point of the disc. The heliographic longitude of the spot is  $l+L$ , where  $L$  is the heliographic longitude of the centre of the disc. The three quantities  $P$ ,  $D$ , and  $L$  for the time of the exposure of each photograph are derived from the Epheris for Physical Observations of the Sun given on p. 520 of the *Nautical Almanac* for 1918.

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The inclination of the Sun's axis to the ecliptic is assumed to be  $82^{\circ} 45'$ ; the longitude of the ascending node for 1918.0 to be  $74^{\circ} 37'.0$ , 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.

### § 2. *General Catalogue of Groups of Sun Spots for 1918.*

The Catalogue contains every group of spots which lasted for two or more days, and the group numbers are in continuation of those given in 1917 and previous years. Groups seen only once are not included, but appear in the Daily Results with a distinctive numeration.

During the year 1918, a number of groups of spots have been noted in the Catalogue as "Revivals." These have been tabulated in series in a table following the Catalogue. The respective groups of each series are in the same heliographic position, and are seen in consecutive rotations but with definite breaks in their history between each rotation. The latter feature excludes them from being classed as "Recurrent" groups; they differ from "Intermittent" groups in their being of long period intermittency. When a "Recurrent" series forms part of a "Revival" series, a reference is made in the last column of the table. Other groups which are given in detail in Ledger II are also indicated.

### § 3. *Ledgers of the Areas and Heliographic Positions of Groups of Sun Spots for 1918.*

*Ledger I.—Recurrent Groups.*—This Ledger supersedes the Catalogue of Recurrent Groups of Sun Spots given in years previous to 1916 of the *Greenwich Photo-Heliographic Results*, and the reference numbers of the series are in continuation of those given therein. The groups forming this Ledger have been abstracted from a general Ledger of all spot groups seen throughout the year, and were selected upon the following plan, reference being made to the General Catalogue:—If any spot group when first seen was  $60^{\circ}$  or more to the east of the Central Meridian, then the Catalogue, and, if necessary, the Daily 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  $60^{\circ}$  or more to the west of the Central Meridian, then the Catalogue was 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 evidence appeared to render probable the continued existence of the spot, it has been numbered in the Ledger, and where there has been some uncertainty a note has been added. If, on the other hand, the evidence appeared to go in the other direction, but was not quite decisive, the series has been printed in the Ledger 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 was not sufficient.

Besides the Ledgers of the groups, there have been printed in a similar manner important components of the principal groups. This has been done in all cases where it appeared probable that an individual component lasted to the second or third rotation after its first appearance.

*Ledger II.—Non-Recurrent Groups.*—This Ledger contains the most important of those groups which do not last to a second rotation. Individual components are also given after their respective groups, where they are large and distinctive.

§ 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 1918.*

Particulars relating to this section are given in the headings on pages D 146-7.

F. W. DYSON.

*Royal Observatory, Greenwich,  
1922 October 2.*



ROYAL OBSERVATORY, GREENWICH.

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POSITIONS AND AREAS  
OF  
SUN SPOTS AND FACULÆ.

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FOR EACH DAY IN THE YEAR

**1918.**

POSITIONS and AREAS of SUN SPOTS and FACULÆ for EACH DAY in the YEAR 1918.

- Col. 1. (1) Time when photograph was taken expressed in days and decimals of a day reckoning from midnight at commencement of year. (2) Place of observatory—Greenwich (G), Cape of Good Hope (C), Kodaikánal (K), Dehra Dún (D). (3) Date of photograph (Civil reckoning).
- Col. 2. Number of Spot Group in order of appearance and in continuation of the Group-numbers given in previous years. Groups seen on one day only are distinguished by the number of the Rotation during which they were observed and by a letter given in the order of their appearance. When there is no number in the second column, it is to be understood that there is a Facula unaccompanied by a Spot.
- Col. 3. Distance of Spot Group or Faculæ from Sun's centre in terms of the Sun's radius.
- Col. 4. Position Angle of Spot Group or Faculæ measured from the North pole of the Sun's axis in the direction N., E., S., W., N.
- Col. 5. Heliographic Longitude of the Spot Group derived from the measures.
- Col. 6. Heliographic Latitude of the Spot Group similarly derived.
- Col. 7. Area of Umbra corrected for foreshortening in millionths of the Sun's visible hemisphere.
- Col. 8. Area of Whole Spots composing the Group similarly expressed.
- Col. 9. Area of each group of Faculæ similarly expressed. 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.
- In line with the date of each day is given in brackets the position angle of the Sun's axis from the North point; the heliographic longitude and latitude of the centre of the disc; the total areas of Spots and Faculæ for the day.

G.M.T. (Civil.)	Group No.	MEASURES.		POSITION.		AREA.			G.M.T. (Civil.)	Group No.	MEASURES.		POSITION.		AREA.			
		Dist.	Pos. Angle.	Long.	Lat.	Umbrae.	Whole Spots.	Faculae.			Dist.	Pos. Angle.	Long.	Lat.	Umbrae.	Whole Spots.	Faculae.	
1918 0.421		.968	252.0	°	°			329	1918 1.350	8374	.986	272.9	93.9	+ 2.3	23	304	382f	
		.937	306.5					155		8382	.985	282.9	92.9	+12.1	0	17	197f	
		.869	247.2					58		8377	.662	262.1	55.2	- 7.7	77	478		
		.860	298.4					168		8378	.626	286.0	51.2	+ 7.4	27	188		
	8374	.931	273.3	94.4	+ 1.9	69	484	452f		859i	.485	299.9	39.3	+11.0	0	4		
	8375	.924	260.5	93.7	- 9.9	13	76	129f		8384	.213	213.6	20.9	-13.3	0	5		
	8382	.934	284.3	93.7	+12.1	8	23	460s	C	8383	.233	353.4	15.6	+10.2	41	222		
	8377	.485	259.6	54.8	- 7.7	84	546			8386	.495	124.8	348.6	-19.2	14	34		
	8378	.460	293.4	51.3	+ 7.7	39	189			8387	.924	81.5	307.3	+ 6.6	106	590	407nf	
	8384	.192	149.3	20.5	-12.5	3	7				.785	67.5					54	
	8383	.300	42.2	14.5	+ 9.7	37	263				.823	51.1					51	
	8386	.607	118.7	352.0	-19.5	3	9		Jan. 2		.942	69.1	(+1.7)	(14.0)	(-3.2)	(296)	(1904)	73
	8387	.984	82.5	307.1	+ 6.8	125	624	139c									(1920)	
		.873	72.1					176										
		.907	54.3					124										
		.920	115.3					73	2.338		.983	292.4					112	
		.939	106.0					114			.953	282.0					129	
Jan. 1		(+2.1)	(26.2)	(-3.1)	(381)	(2221)	(2377)				.916	265.5					239	
											.905	298.7					109	
											.864	245.2					67	
										8377	.814	263.0	55.4	- 7.7	78	443	200c	
									C	8378	.780	282.2	51.0	+ 7.4	26	169	157c	
		.975	301.9					82		8383	.326	314.8	14.5	+10.0	32	241		
		.947	246.7					112		8386	.342	146.2	349.4	-19.7	5	30		
		.940	294.1					155		8387	.816	79.6	307.3	+ 6.6	105	619		
		.857	286.3					70			.852	66.4					65c	
		.848	209.8					74			.927	79.4	(+1.2)	(1.0)	(-3.3)	(246)	(1502)	40
		.823	265.3					129	Jan. 3								471	
	8375	.985	260.3	94.2	-10.2	8	62	134f									(1589)	

Group 8374, 1917, Dec. 21-1918, Jan 2. A very large regular spot with a small companion to the s. From Dec. 24-28, a nebulous cluster of very small spots follows the principal spot.

Group 8375, Dec. 21-Jan. 2. A close pair of spots which coalesce to form a regular spot by Dec. 23. A few very small markings follow the spot on Dec. 27.

Group 8377, Dec. 24-Jan. 5. Revival in region of Group 8344. A large stream of normal type, but in which the leader becomes exceptionally large and the rear spot correspondingly small. The umbra of the leading spot is crossed by "bridges" from Dec. 27-31.

Group 8378, Dec. 24-Jan. 5. Return or revival of Group 8340; on the same meridian as Group 8377. A regular spot slowly contracting. There are a few companions from Dec. 29-Jan. 3.

Group 8382, Dec. 27-Jan. 2. A stream of small spots, *n* Group 8374, of which the last becomes prominent on Dec. 29, but is soon disappearing.

Group 8383, Dec. 27-Jan. 8. A regular spot with a short train of small followers until Jan. 5.

Group 8384, Dec. 28-Jan. 2. A wide pair of very small spots, of which the following is alone visible after Dec. 31.

Group 8386, Jan. 1-6. A short stream of very small spots.

Group 8387, Jan. 1-13. Return of Group 8354. Two large regular spots. The preceding one is the smaller and is gradually disappearing whilst its umbra becomes composite.