RESULTS OF MEASURES MADE AT THE
ROYAL OBSERVATORY, GREENWICH, OF

PHOTOGRAPHS OF THE SUN

TAKEN AT GREENWICH, THE CAPE
AND KODAIKANAL IN THE YEAR

1942

UNDER THE DIRECTION OF

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ASTRONOMER ROYAL

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CORRIGENDUM

GREENWICH PHOTO-HELIOGRAPHIC RESULTS, 1941.

Title page on C 91 delete "and Solar Flares". (A table of solar flares for the years 1930 to 1944 will be given in the volume for 1944.)

GREENWICH
PHOTO-HELIOGRAPHIC RESULTS
1942

INTRODUCTION

§1. *Positions and Areas of Sunspots and Faculae for each Day in the Year 1942.*

The photographs from which these measures were made were taken at the Royal Observatories of Greenwich or of the Cape, and at the Kodaikanal Observatory, Southern India.

The photographs of the Sun obtained at Greenwich were taken with the Dallmeyer Photoheliograph, of which the original 4-inch object-glass had been replaced in 1910 by a Grubb photographic objective. The equivalent focal length of the photoheliograph with its present enlarging system (supplied in 1926 by Ross Ltd.) is 67½ feet, the diameter of the Sun's image at the secondary focus being 7½ inches at the Earth's mean distance.

The photographs from the Cape Observatory were taken under the superintendence of His Majesty's Astronomer at the Cape, Dr. J. Jackson, and those from Kodaikanal under the superintendence of the Director, Dr. A. L. Narayan. At the Cape Observatory the instrument employed was a Dallmeyer photoheliograph giving an image of the Sun about 7½ inches in diameter; at Kodaikanal a Cooke photo-visual object-glass of 6 inches aperture was used, the image of the Sun being on about the same scale.

Photographs of the Sun were available for measurement on 364 days in 1942, those finally selected for measurement being supplied by the three observatories as under:

Greenwich	241
Cape	118
Kodaikanal	5
Total	364

For the one missing day, a copy of an original solar negative was kindly supplied by the U.S. Naval Observatory, Washington, D.C.

The names of the measurers of the photographs for the year 1942 are as follows:

H. Barton
P. S. Laurie
Miss C. Chapman

At the principal focus of the photoheliographs, excepting that at Kodaikanal, two spider-lines are fixed by which the zero of position-angles on the photographs can be determined. These lines are inclined at an angle of 45° to the celestial equator in the Greenwich and Cape photoheliographs; in the Kodaikanal instrument there is one wire fixed parallel to the equator.

The zero of position-angles for the 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. Two zero photographs were usually taken each month at Greenwich and at the Cape.

At Greenwich and the Cape, transits of the Sun were also taken over the two wires; the times of contact of the first and second limbs of the Sun with the two wires being noted. The ratio of the time taken by the Sun to pass over the NE - SW wire to that taken to pass over the SE - NW wire gives the tangent of the angle made by the Sun's path to the latter wire, the wires being assumed to be at right angles to each other. From this angle, when corrected for the Sun's motion in declination, the correction for the zero position of the wires can be inferred. Transits were taken usually on four or more days during each month.

The following table gives the correction for zero of position thus determined by the two independent methods for the 4-inch Greenwich and Cape photoheliographs.

Determination of Zero of Position-Angles.

Month, 1942	Greenwich		Cape	
	Photographic	Visual	Photographic	Visual
	° ′	° ′	° ′	° ′
January	+ 1 58	+ 1 54	+ 1 34	+ 1 24
February	..	+ 1 50	+ 1 48	+ 1 22
March	+ 1 51	+ 1 52	+ 1 37	+ 1 24
April	+ 1 47	+ 1 51	+ 1 30	+ 1 24
May	+ 2 00	+ 1 56	..	+ 1 27
June	+ 1 56	+ 1 54	+ 1 28	+ 1 26
July	+ 1 58	+ 1 57	July 1-8 +0 55	+ 1 04
			" 9-21 −0 05	− 0 09
			" 22 −0 18	− 0 23
			" 23-31 +1 02	+ 1 09
August	+ 2 00	+ 1 58	+ 1 12	+ 1 09
September	..	+ 1 54	+ 1 13	+ 1 10
October	+ 1 56	+ 1 58	+ 1 09	+ 1 08
November	..	+ 1 55	+ 1 19	+ 1 08
December	+ 1 47	+ 2 00	+ 1 12	+ 1 10

The zero-corrections used during the year 1942 in the reduction of the Greenwich photographs were as follows:-

	° ′
January 1 to April 30	+ 1 51
May 1 to December 31	+ 1 57

The cross-wires of the photoheliograph at the Cape Observatory were changed after June 29, and the zero-corrections used during the year 1942 in the reduction of the photographs were as follows:-

January 1 to March 31	+ 1° 30′
April 1 to June 29	+ 1 27
July 1 to 8	+ 1 00
July 9 to 21	- 1 06
July 22	- 0 21
July 23 to December 31	+ 1 09

The zero-correction adopted for the Kodaikanal photographs ranged from +0°.1 to +0°.4.

The measures of the photographs were made with a large position-micrometer which can be used for 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 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 negligible. The distance of a spot or facula from the centre of the disk is read off by means of a scale and vernier to 1/250th 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° between the photograph and the plate below.

The majority of the plates for 1942 were measured once, each by an experienced measurer. The remaining plates were measured twice independently, the two measurers taking right and left readings respectively with the micrometer. To the single measures of position, small corrections have been applied equivalent to half the instrumental difference between right and left scale readings applicable to the current adjustment of the position micrometer.

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 had 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 disk, R the measured radius of the Sun on the photograph, (R) the tabular semi-diameter 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, ρ is obtained from the equations:

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

If D and ϕ 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

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

χ is found from the position-angle measured from the north point by subtracting P, the position-angle of the north end of the Sun's axis, measured eastward from the north point of the disk. The heliographic longitude of the spot is l + L, where L is 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. 394 of the *Nautical Almanac* for 1942.

The inclination of the Sun's axis to the ecliptic is assumed to be 82°45′, the longitude of the ascending node of the Sun's equator on the ecliptic for 1942.0 to be 74°57′.0, and the period of the Sun's sidereal rotation to be 25.38 days; the meridian which passed through the ascending node on 1854 January 1, Greenwich mean noon, being taken as the zero meridian.

§2. *General Catalogue of Groups of Sunspots for* 1942.

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 1941, and previous years. Groups seen only once are given with a distinctive numeration in a table which follows the catalogue.

A number of "Revival" groups of spots have been tabulated in series in a table following the catalogue and table of 1-day spots. The respective groups of each series are in the same heliographic position and were seen in consecutive disk passages, partial or complete, but with definite breaks in their history between each passage. 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 Sunspots for* 1942.

Ledger I. - Recurrent Groups. - This ledger supersedes the *Catalogue of Recurrent Groups of Sunspots* 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° or more to the east of the central meridian, then the catalogue, and, if necessary, the daily results also (§1), 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, then a search was made to identify with the earlier group, any spot near the Sun's east limb, about a fortnight later. When there appeared to be a case of probable identity between groups in consecutive rotations of the Sun (in some cases, partial transits of the disk), then the character of the group, its area, longitude and latitude, have been carefully compared before accepting its continuity as a recurrent group.

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.

In deriving the proper motions of spots in longitude in both ledgers, the formula adopted as representing the Sun's daily sidereal motion is

$$\xi = 14^\circ.37 - 2^\circ.60 \sin^2 \phi$$

where ϕ is the latitude of the spot. *See Greenwich Photo-Heliographic Results,* 1924, §5.

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 Sunspots and Faculæ for each day, and Mean Areas and Mean Heliographic Latitude of Sunspots and Faculæ for each Rotation of the Sun, and for the year* 1942.

Particulars relating to this section are given in the headings on pages C 66 and C 70-1.

§5. *Observations of Solar Flocculi made with the Spectrohelioscope in the year* 1942.

This section contains measures of radial velocity of dark hydrogen flocculi seen on the Sun's disk near sunspots. The observations were made at Greenwich with a spectrohelioscope lent by the Mount Wilson Observatory in the autumn of 1929 and set up in the south attic of the Main Building. The observations were made by Mr. Barton and Mr. Laurie.

ROYAL OBSERVATORY, GREENWICH.

Positions and Areas of Sunspots and Faculæ

For each Day in the Year

1942

POSITIONS AND AREAS OF SUNSPOTS AND FACULÆ FOR EACH DAY IN THE YEAR 1942.

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 observation – Greenwich (G), Cape of Good Hope (C), Kodaikanal (K), Washington (W). (3) Date of Photograph.

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 umbræ 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 for the time of photograph the position angle of the Sun's axis from the north point: the heliographic longitude and latitude of the centre of the disk: the total areas of spots and faculæ for the day.