THE ROTATIONAL MOTIONS OF SUNSPOTS

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Introduction

Owing to a large number of papers on the rotational motions of sunspots, it may be assumed that these motions have been positively verified. It turned out from an examination of the daily graphs of the solar magnetic field observations, which were made at the Mount Wilson Observatory during the years 1917—1924, that some spots apparently show motions which indicate rotation in the plane of the photosphere or oscillations of this rotational motion.

Method of Investigation

The catalogue of the daily solar graphs mentioned above (Hale and Nicholson, 1938) containing 1615 sunspot groups, has been used as basic observational material. But only the spots for which the rotation was explicitly observed for at least three days, and which were within $\pm 65°$ of the central meridian, were selected. For each spot a characteristic direction was fixed and its angle with the N-S line (meridian) was estimated. This angle then became the essential factor for estimating the speed and sense of the spot rotation for each day. The characteristic direction was drawn according to specific characteristic marks which could be identified in the spot over at least three days. The characteristic marks of the spots were, e.g., an elongated umbra, a double core of the spot, a couple of small spots which later formed the core of spot. The angles between the characteristic directions and the N-S meridian were measured by a simple graphic method with an accuracy of about $\pm 1°$.

Results

Of all the 1615 sunspot groups observed it was possible to estimate positively a rotation for 133 groups. In these groups 146 particular spots had rotated. These 133 groups with rotating spots amout to 8.2% of the total number of investigated groups. It is necessary to bear in mind that it is very difficult to define the rotation of the spots from the drawings used and in a large number of cases this is obscured by evolutionary changes in the spots.

It was only possible to fix a characteristic direction simultaneously for both lesding L and following F spots for a very small number of spots (12 groups only).

The rotation of the characteristic direction was observed in spots over time intervals of 3 to 10 days. The most frequent interval, over which it was possible to identify the characteristic direction without doubt, amounted to 4 days.

A detailed day-by-day study of the characteristic direction shows that it changed in way, which could be described as a rotation or oscillation of the investigated spot. All spots with an established rotational motion were divided into two groups according to the predominating direction of rotation. This division showed that one rotational direction of the spots (ENW) prevailed and that it amounted to 87 cases. This is 60% of the total number of the rotating spots. The remaining 59 spots (40%) had the opposite rotational direction — WNE. In some cases the rotating spots changed their direction of rotation. The distribution of the spots according to the direction of rotation for the northern and the southern hemisphere, respectively, is shown in Table 1.

It is remarkable that in both hemispheres the

Table 1

Hemisphere	ENW	WNE
N	51	33
S	36	26

same direction of rotation (ENW) predominated. Furthermore, Table 1 was investigated as to the leading L and the following F spots. The results are given in Table 2.

Table 2

	ENW		WNE	
Hemisphere	L	F	L	F
N	40	11	23	10
S	33	3	21	5

The dependence of the number of rotating spots on the heliographic latitude was investigated too. The Sun was divided into 10° zones. Table 3 gives the numbers of the rotating spots in the separate zones for both directions of rotation. We can see from this table that most of the rotating spots occur in the zone from 10 to 20° on both hemispheres.

This corresponds with Spöres' law of the occurrence of sunspots, and it gives probably us the evidence for the independence of the occurrence of the rotational direction of separate spots on heliographic latitude.

Table 3

Zone	ENW		WNE		Sum
	L	F	L	F	
4N	—	1	—	—	1
3N	4	1	2	1	8
2N	24	3	11	6	44
1N	12	6	10	3	31
1S	15	1	2	2	20
2S	17	2	15	2	37
3S	1	—	4	1	6

Finally, the rotation of spots was investigated according to its dependence on the total area of the group. When we compare the course of the rotation of the particular spots with the evolution of the total area of the group, we find that the rotation of the separate spots was observed mostly at the time of the largest group area (the beginning of rotation), or close to the maximum of its development.

To conclude our short note, we assume from our results and from the results of other authors, Abetti (1932), Nikitenko (1963), that the predominant direction of the rotational spot motion is ENW, both for the northern and the southern hemisphere of the Sun. Since the same direction of the rotational spot motions predominates on both solar hemispheres, we may be able to assume that this motion is not the direct consequence of the differential solar rotation, or of Coriolis' force.

References

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