SUNSPOT MOTION IN HALE REGION No. 18430

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ABSTRACT. On the basis of sunspot positions, measured on full-disc white-light heliograms, the spot motions of a new solar active region have been studied. All spots were followed from birth over their whole discpassage in the period of June 16-26, 1982. Within a few days a large sunspot group was fully developed that was associated with a number of major flare occurrences (two of them have been reported even as white-light flares).

ДВИЖЕНИЕ СОЛНЕЧНЫХ ПЯТЕН В ОБЛАСТИ ХЭЛА № 18430: На основании положений солнечных пятен, измеренных на фотогелиограммах полного диска в белом свете, исследовались движения пятен в новой активной области. Все пятна были прослежены от их рождения в течение всего времени их прохождения по диску Солнца с 16 по 26 июня 1982 г. В течение немногих дней полностью развилась большая группа, связанная с появлением больших вспышек (о двух из них сообщалось, как вспышках в белом свете).

POHYB SLNEČNÝCH ŠKVŔN V OBLASTI HALE No. 18430. Na základe polôh slnečných škvŕn, zmeraných z fotoheliogramov celého slnečného disku, boli vypočítané pohyby škvŕn v novej aktívnej oblasti. Všetky škvrny boli sledované kontinuálne, od 16. do 26. júna 1982. Pohyby škvŕn sú určené pre celý čas ich trvania, od ich vzniku pokračovali merania počas celého prechodu škvŕn cez slnečný disk. V priebehu niekoľkých dní sa úplne rozvinula veľká skupina škvŕn. V skupine vznikle niekoľko mohutných erupcií (dve z nich boli pozorované v bielom svetle).

1. INTRODUCTION

We think, that nowdays it is already the general opinion that some mass motions in the solar atmosphere play somehow an important role in the flare build-up process. Obviously, the relative motion of smaller local plasma regions of north and south magnetic polarities are of particular importance. However, it is well known that alone, the familiar large divergent motion itself of the p and f spots of a young bipolar sunspot group, does not produce flares. The start of flare activity in relation to a group in its phase of early development usually takes place only after new magnetic flux emergence occurs there or if nearby there was another spot group preexistent. Should the case occur that the two spots do not belong to the same spot group, the high relative velocity and perhaps also the rapid approach of the two spots of opposite polarity may trigger flares. In the past years we have shown (Dezsö et al., 1980, Dezsö and Kovács, 1981, Kovács, 1977) examples of this kind which clearly demonstrated that such sort of relative spot motions may be considered at least as preliminary steps for flare development.

On the other hand it is well known that large spot groups with complex magnetic structure and/or groups in a period of rapid growth usually reveal great flare activity. Both of these characteristics are closely concomittant to spot motions of relatively high velocities (i.e. a few tenths of km s^{-1}). We are inclined to think from some foregoing papers (loc. cit., Nagy and Ludmány, 1980) that in principle even the most complex sunspot groups are made up of simple bipolar groups close to each other and any member of these simple groups essentially consists only of a few pairs of spots of opposite polarity. On the supposition that this is a correct statement on the whole, we have investigated in this view in mind the spot motions in Hale region 18430 in association with its most prominent major flares.

2. THE MATERIAL OF OBSERVATIONS

Nearly 200 heliograms have been used, the majority taken in Debrecen by L. Kondás and the rest in Gyula by F. Seres, L. Győri and I. Lengyel. Most of the umbrae seen separated in Hale region 18430 (dominated by sunspot group Mt.Wilson no. 21189 = Soln. Dann. No. 207, 1982) have been measured on the 10 cm solar disc photographs and their Carrington coordinates were calculated. For more details about observations, measurements and data reduction see our earlier papers (e.g. loc.cit.). The magnetic spot polarities determined at the Mt.Wilson and Yunnan observatories have been used. Flare data were taken from Solar-Geophysical Data.

3. DIRECT OBSERVATIONAL RESULTS

On June 16, 1982, in the early morning, near the east solar limb (at about 68^{o} central meridian distance) in a crescent-shaped photospheric plage an apparently simple regular bipolar sunspot group has been born. In a few days it developed to a large complex group and was studied by us as long as its whole extent could be observed (within 80^{o} from central meridian). It was classified at Mt.Wilson over 6 days for a δ-group.

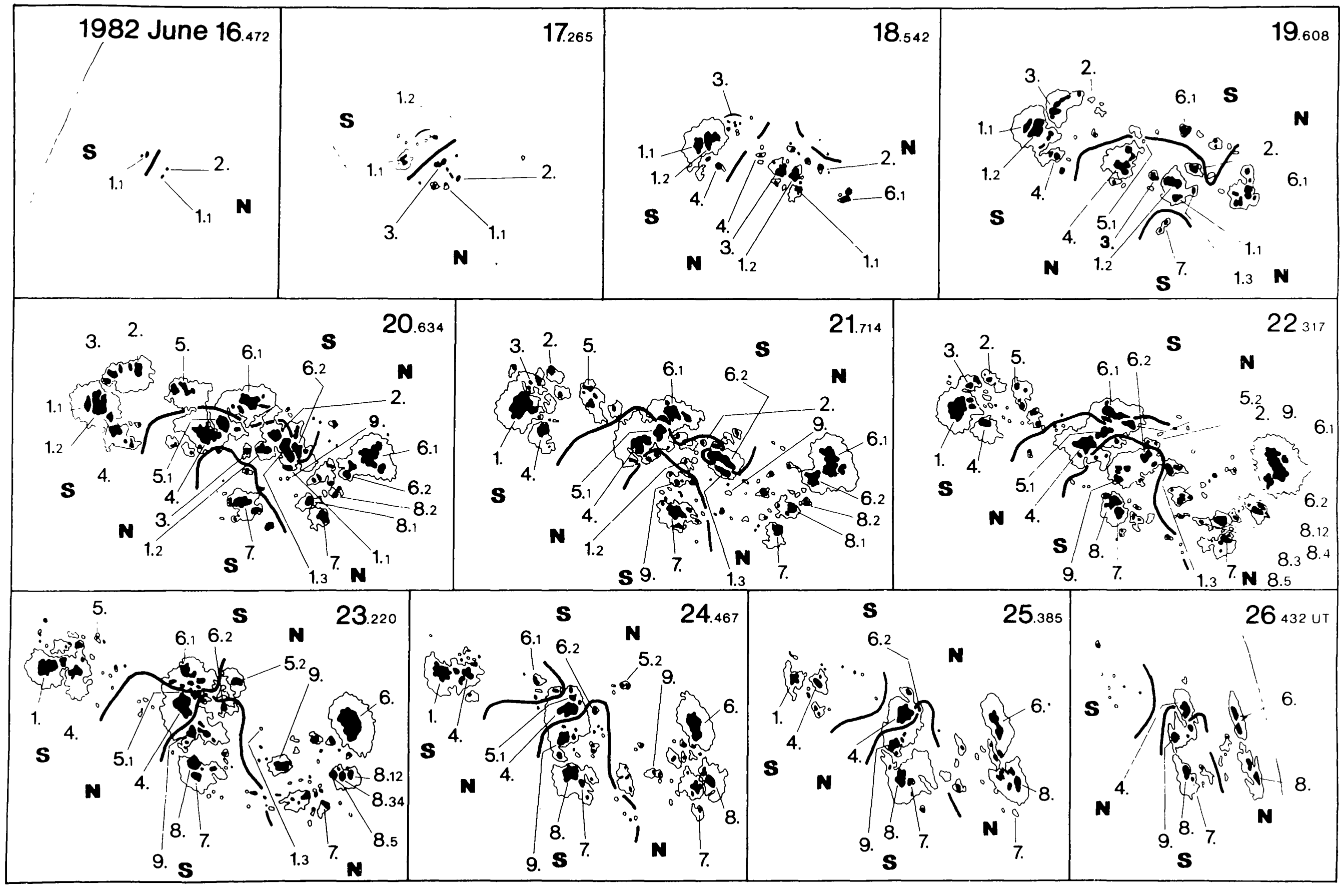

Fig. 1: The development of the sunspot group Mt.Wilson 21189, as seen on the Sun's disc. (North is up.)

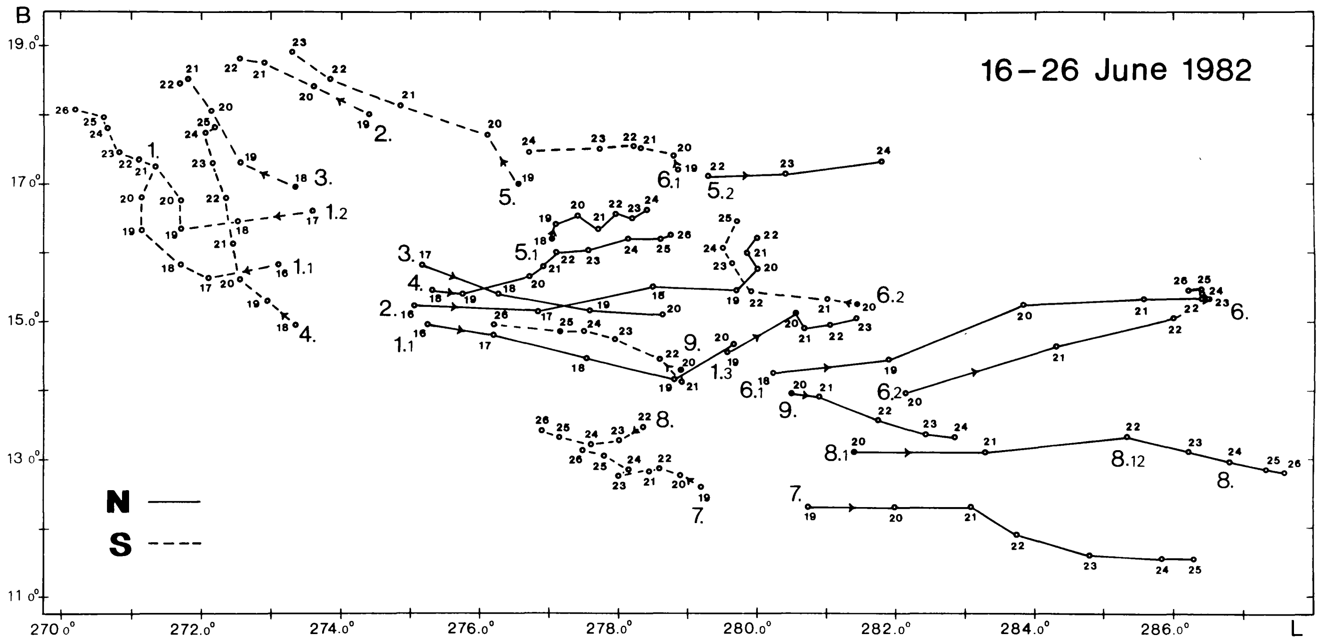

Fig. 2: Sunspot motions over the network of Carrington coordinates (L,B). The designation of spots corresponds to Fig. 1. For each spot only one daily mean position and the relevant date are shown (the positions are roughly 3 hourly averages of about 8 observations); open circles are morning (about 6 UT) positions, while a few (6) dots show later positions if the spot was born during the day.

We didn't have any trouble at all to mark 9 regular bipolar groups off from this complex group as demonstrated in Fig. 1. Generally, every single important spot is denoted by a group number and a serial number (the large number and the smaller number in Fig. 1 respectively). In some cases a cluster of near small spots are branched and denoted accordingly. In addition, the letters N and S indicate the north and south, i.e. the p and f polarity spots respectively (in Fig. 1 it was not necessary to show them all individually). A group number alone stands for the whole p or f polarity part of the group, i.e. usually, in practice, for the main p or f spot. (After the group number, the serial number 1 marks the principal spot of the p or f part of a group). The irregular heavy lines in Fig. 1 show the approximate positions of the magnetic inversion line.

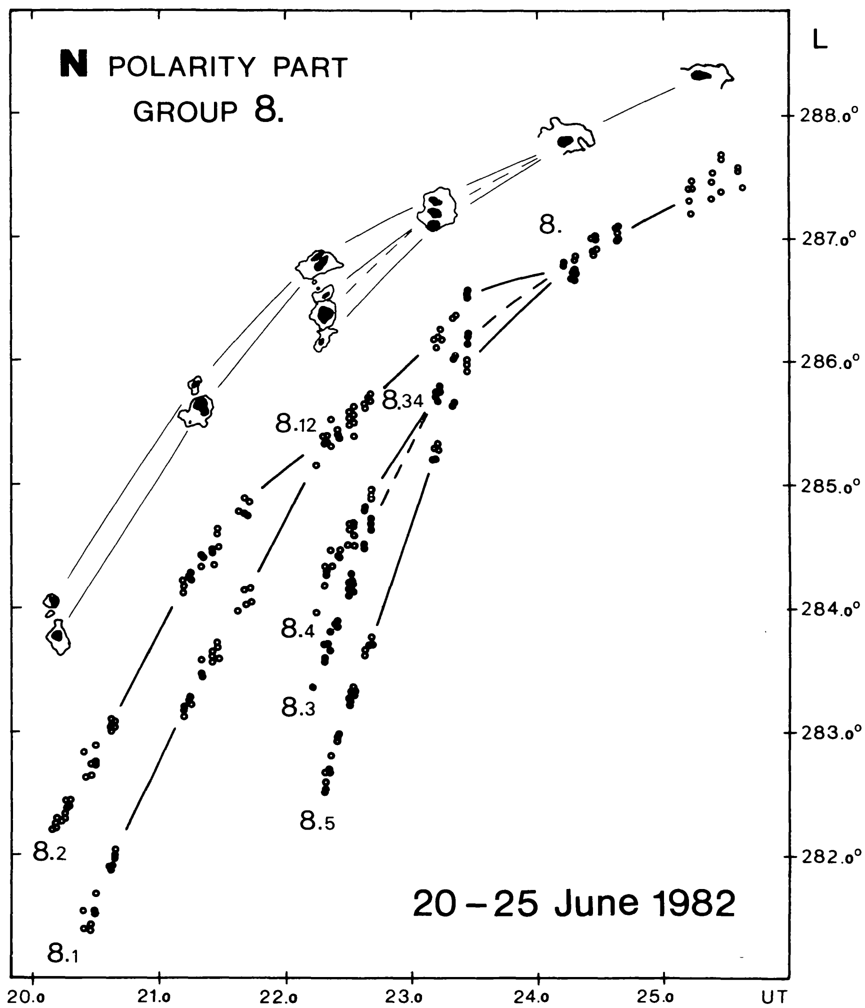

Fig. 3: The development of the spot 8 of p polarity by spot-coalescence through rapid motion. The spot drawings are taken from Fig. 1.

Already a brief survey over the daily pictures in Fig. 1 gives strong evidence for a very high activity. One cannot help noticing some spot motions from one day to the next, as well as fast spot developments and sudden structural variations. Since with the exception of one day we have for each day a long enough several-hour period of observation, we could follow and identify almost all spots overnight in spite of the great and quick changes from one day to the other.

The motion of all important spots of our 9 groups are shown in Fig. 2. It is seen at a glance that in each group the p and f spots all reveal definite regular divergent motion.

As usual, most of the principal p and f spots were grown through the motion and coalescence of several small spots. A characteristic example is given in Fig. 3, where every single position in longitude determined is plotted demonstrating at the same time the accuracy of our measurements.

Table 1

Flares and the nearby sunspots observed in Hale region 18430

Date 1982 June	Time UT	Imp. Hα	Imp. X-ray	Spots	Date 1982 June	Time UT	Imp. Hα	Imp. X-ray	Spots
20	17:12	1B		S7.1	23	02:36	1N	C 4.1	S5.1
	22:28	1N	M 3.6	N2.1,S6.2		06:43	2N	M 4.4	N5.1,N5.2,S6.1
21	01:13	1N	M 3.6	N1.2,S9.1		11:59	1N		N5.1,N5.2,S6.2
	02:49	1N	M 1.9	N6.1		18:42	1B	M 1.0	N4.1,S6.2,S9.1
	16:11	1B	M 3.6	N1.3,N2.1,S6.2		23:32	1B		N4.1,S6.2,S9.1
	22:17	1N	M 1.3	N1.3,N2.1,S6.2		23:49	1N		N5.2
	23:55	1B		N1.3,N2.1,S6.2	24	04:15	1B	C 9.0	N8.
22	01:28	1N		N1.3		05:24	1N	M 2.0	N5.1,N4.1,S6.2
	05:17	1B	M 2.5	N2.1,N5.2,S6.2		05:28	1B		N6.2
	06:29	1N		N1.3	25	19:44	2B	M 2.0	S4.1
	10:26	1B		N4.1,S8.1,S9.1		21:37	2B*	M 7.5	N4.1,S9.1
	14:36	1B	M 3.8	N5.2	26	00:46	2B	X 1.9	N4.1,S9.1
	18:33	1B	M 2.7	N5.1,N5.2,S6.2		09:20	2B		S9.1
						09:42	1N		S9.1
						19:12	2B*	X 2.1	N4.1,S9.1

Flares ≥Imp.1, according to Solar-Geophysical Data.
* white-light flares (Neidig and Cliver, 1983)

4. DISCUSSION

The roots of our 9 spot groups were concentrated mainly at about two longitudes: groups 1.-4. at 274^{o} and groups 6.-9. at 280^{o}, while between them at

277° was group 5. In the course of June 16-18 the groups 1.-4. came into appearance and later the five others during June 18-20. As both the distance between the two local active longitudes and the time delay among the spot emergences have been relatively short enough, the usual rapid initial divergent motion of the young bipolar groups easily brought about several δ-configurations. In addition, it also occurred that some umbrae of different groups but having the same polarity got quite near to each other in a common penumbra but even in this case they really never have merged. This behaviour supports our method of grouping the spots into simple groups.

Table 2

Spot velocities
(determined by least square estimations)

Spot	Interval 1982 June	Number of obs.	$\frac{dL}{dt}$ km s^{-1}	$\frac{dB}{dt} > 0.01$ km s^{-1}	Umbra areas (corrected) 10^{-6} solar hemisph.
S6.2	20 - 21	39	-0.06 ±0.01		3 - 14
	21	21	-0.06 ±0.01		14
	21 - 22	44	-0.14 ±0.02	+0.02 ±0.01	14 - 4
	22 - 23	38	-0.03 ±0.01	+0.06 ±0.01	4 - 3
	24 - 25	27	+0.03 ±0.01	+0.04 ±0.01	3 - 1
N1.3	19 - 20	35	+0.13 ±0.01	+0.07 ±0.02	1 - 3
	20 - 21	46	+0.01 ±0.01	-0.04 ±0.01	3 - 9
	21	21	+0.02 ±0.01		9
	21 - 23	58	+0.06 ±0.01		9 - 1
N2.1	16 - 18	34	+0.23 ±0.02	+0.02 ±0.02	1 -
	19 - 20	35	+0.05 ±0.01	+0.06 ±0.01	- 10
	21 - 22	32	+0.02 ±0.01	+0.03 ±0.01	3 - -
S6.1	20 - 23	84	-0.04 ±0.01		13 - 6
	23 - 24	32	-0.16 ±0.02		6 - 2
N5.1	20 - 24	103	+0.03 ±0.01		13 - 6
S9.1	21 - 22	44	-0.05 ±0.01	+0.05 ±0.01	1 - 7
	22 - 24	58	-0.07 ±0.01	+0.02 ±0.01	7 - 12
	24 - 26	51	-0.09 ±0.02		12 - 14
N4.1	21 - 22	44	+0.03 ±0.01	+0.03 ±0.01	23 - 26
	22 - 24	58	+0.06 ±0.01	+0.02 ±0.01	26 - 29
	24 - 26	51	+0.02 ±0.02		max.34
N8.1	20 - 21	34	+0.29 ±0.01		
	22 - 23	38	+0.13 ±0.01	-0.04 ±0.01	
	24 - 25	36	+0.09 ±0.03	-0.02 ±0.01	
N8.2	20 - 21	44	+0.24 ±0.01	+0.05 ±0.02	
N8.3	22 - 23	34	+0.32 ±0.01	+0.06 ±0.01	
N8.4	22 - 23	34	+0.23 ±0.01	+0.03 ±0.01	
N8.5	22 - 23	34	+0.41 ±0.02	+0.07 ±0.02	

It should be mentioned that magnetic shearing came into being in several places for a considerable time through spot motions which were originated mainly from spots S9. and S6.2, and further partly from S6.1. The high flare activity must be attributed to these shearings.

All important flares observed in the solar region studied are listed in Table 1, where in most cases all those relevant nearby spots which were certainly associated with the flare are also given. Here, it is clearly seen again that two of the spots S9. and S6.2 played the most important role in the flare activity of the region. In Table 2 there are several typical examples of velocities of spot motions over the Carrington coordinate network. It is interesting to compare the velocity data of the young p spots of group 8. which moved unhindered with that of the spots producing magnetic shear. There are, as usual, lower velocity values in the case of spots last mentioned.

5. CONCLUSION

It has been demonstrated that it is possible to recognize more or l bipolar sunspot pairs as the constituting elements of a magnetically com large sunspot group. Consequently, we should consider such groups as it were build-up from several simple bipolar sunspot groups. By this means, it seems to be more promising to study the associations between flare build-up and the physical properties of sunspot groups.

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