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THE EAST-WEST ASYMMETRY OF SUNSPOTS

Abstract: The east-west asymmetry in sunspots observed at Skalnaté Pleso is not systematically positive: it shows a marked dependence on the 11-year cycle, as it is positive with rising and high activity, and negative when activity declines or is low. A similar dependence was reported also by other stations.

The number of groups in the Zurich material has almost systematically been higher in the west since 1933, in other words, the asymmetry has been negative. Negative asymmetry in the number of groups and the spot area over relatively longer periods has also been reported by other stations these last decades. This inconsistent result of different stations suggests the conclusion that both positive and negative asymmetry may have more reasons.

The material obtained at Skalnaté Pleso, as an independent station, was examined for the effect of meteorological conditions, and the result was as follows: 1. Asymmetry is positive for most years with above-average precipitation, negative for those with below—average precipitation. 2. Groups of the type D, E and F observed for at least 13 days have better atmospheric observational conditions before than after the central-meridian passage.

Negative asymmetry may be explained by a psychologic factor which is more pronounced during decreasing and low solar activity than at its maximum.

In supplemented series of observations (Zurich), the meteorological factor is eliminated precisely by supplementing the missing days, while the effects of the psychologic factor may cumulate. The effects of these two factors may be eliminated by the photographic method in certain conditions.

The East-West Asymmetry in Spots

Introduction

The problem of the east-west asymmetry in solar activity was set by A.S.D. Maunder (1907) as early as 1907. She found that groups were larger in both number and area on the eastern than on the western half of the solar disc. She determined three asymmetry types for spots. This east-west asymmetry has been investigated by numerous astronomers ever since, the results, however, were not unambiguous. Topmost among the hypotheses framed to explain this phenomenon, were those of the unfavourable effect of the Earth and of the other planets on solar activity, and of a possible inclination of the spot axis.

We shall deal with the east-west asymmetry observed at Skalnaté Pleso in the Wolf number and in the number of groups. The results obtained permitted us to check one of the factors possibly responsible for positive asymmetry, that is the factor of meteorological conditions. The effect of meteorological conditions on the asymmetry examined may only be accurately checked from observations made at one station. In a supplemented observational series, such as in the Zurich material, the meteorological effect may be completely blurred, the missing days and low-quality observations due to poorer meteorological conditions being supplemented and replaced by observations made from stations with favourable observational conditions.

The asymmetry values in the present paper will be designated and defined as in the papers by F. Link and Z. Linková (1957), and Ľ. Pajdušáková (1958 and 1966):

E activity of a given phenomenon (expressed in corresponding units) on the eastern half of the solar disc.

W	same for the western half of the solar disc.
E + W	total activity of the phenomenon all over the solar disc.
E — W	total asymmetry of a given phenomenon.
$\frac{E - W}{E + W}$ %	relative asymmetry in per cent of a phenomenon.
$\sum(E - W)$	cumulative sum of the total asymmetry of a phenomenon.

Asymmetry in the Wolf number

The photosphere has systematically been plotted at the Astronomical Institute Skalnaté Pleso since October 1944 (in projection, solar image 25 cm in diameter). From that time on until 8 October 1953 the observations were made with a Zeiss B objective, 13 cm in dia., 195 cm focal length. Since then until now, the observations have been made with a Zeiss E objective, 24 cm in dia., 304 cm focal length. The Wolf numbers of the eastern and western half of the solar disc were determined by normal method from daily drawings. The weight of a group located on the central meridian direct was assigned to the half with the major part of the group. The dividing line of the number of spots in the group was the central meridian. The monthly averages were determined from diurnal values and the monthly smoothed Wolf numbers were computed from monthly averages.

The period examined includes the 18th and 19th cycle of solar activity; the number of photosphere drawings processed is more than 5 000.

Wolf's definition of the sunspot number implies that the asymmetry in the number of groups and individual spots, that is umbrae, is projected into the asymmetry of the Wolf number.

The observed monthly Wolf numbers for the eastern —E— and western —W— half of the solar disc, together with the total and relative asymmetry and the cumulative sums of the total asymmetry, are listed in Tab. I.

The same data for the smoothed out monthly Wolf numbers are in Tab. II. The variations in the smoothed out monthly Wolf numbers for both halves of the solar disc are given in Fig. 1; the variations in the cumulative sums of the total and relative asymmetry in Fig. 2.

The variations in the asymmetry of the smoothed out monthly Wolf numbers are as follows: Positive asymmetry prevailed from almost the minimum in 1944 until the end of 1948, so that Wolf numbers were larger on the eastern half of the solar disc over this period.

This was followed by a prevalence of the western half, that is by a systematic negative asymmetry, which roughly lasted until minimum solar activity. The period of fast increase and maximum of solar activity which followed was characterized by prevailing positive asymmetry until 1960, succeeded again by negative asymmetry.

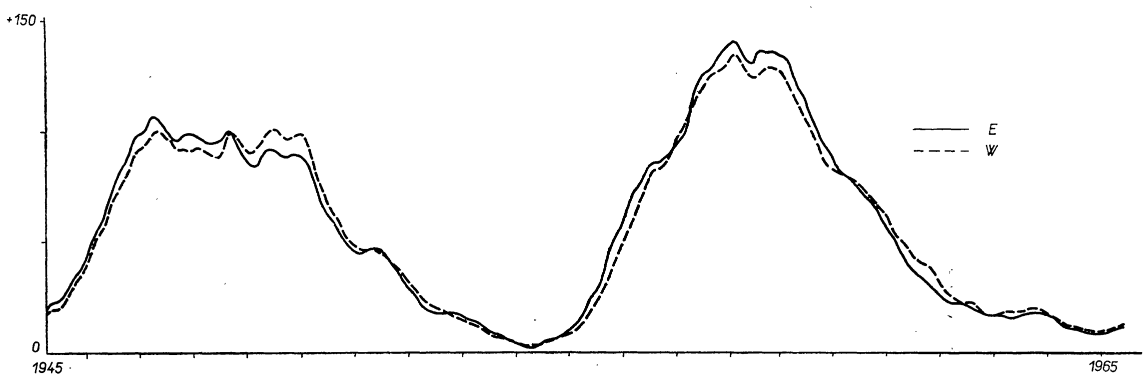

Figure 1. Variations in the smoothed out monthly Wolf numbers for the eastern half (——) and for the western half (- - - -) of the solar disc—Skalnaté Pleso.

The asymmetry in the Wolf number, positive or negative, is not distributed accidentally over the individual months, as might be expected from the fact that „eastern and western half of the solar hemisphere" are terms senseless on the Sun, which only exist with reference to the Earth. The percentage of the number of months in the given periods with either positive or negative asymmetry is very high, especially for the smoothed out monthly numbers, as is seen in Tab. III.

Table I

Observed monthly relative numbers in the eastern and western hal of the solar disc and their asymmetry—Skalnaté Pleso

Year	Month	E	W	E — W	Σ(E — W)	$\frac{E-W}{E+W}$ %
1944	X.	10.9	9.2	+1.7	+1.7	+8.46
	XI.	9.2	8.7	+0.5	+2.2	+2.79
	XII.	23.1	28.5	—5.4	—3.2	—10.47
1945	I.	9.5	10.5	—1.0	—4.2	—5.00
	II.	10.6	8.1	+2.5	—1.7	+13.37
	III.	15.9	7.5	+8.4	+6.7	+35.90
	IV.	21.2	19.3	+1.9	+8.6	+4.69
	V.	20.3	27.0	—6.7	+1.9	—14.16
	VI.	26.9	22.6	+4.3	+6.2	+8.69
	VII.	29.9	27.9	+2.0	+8.2	+3.46
	VIII.	22.4	13.4	+9.0	+17.2	+25.14
	IX.	23.6	15.3	+8.3	+25.5	+21.34
	X.	45.4	37.8	+7.6	+33.1	+9.13
	XI.	24.6	29.8	—5.2	+27.9	—9.56
	XII.	16.6	12.1	+4.5	+32.4	+15.68
1946	I.	39.0	33.2	+5.8	+38.2	+8.03
	II.	50.5	47.8	+2.7	+40.9	+2.75
	III.	56.3	57.9	—1.6	+39.3	—1.40
	IV.	54.9	48.1	+6.8	+46.1	+6.60
	V.	59.9	71.6	—11.7	+34.4	—8.90
	VI.	55.7	47.7	+8.0	+42.4	+7.74
	VII.	105.3	90.5	+14.8	+57.2	+7.56
	VIII.	78.4	75.8	+2.6	+59.8	+1.69
	IX.	73.2	75.5	—2.3	+57.5	—1.55
	X.	64.7	64.8	—0.1	+57.4	—0.08
	XI.	107.4	86.3	+21.1	+78.5	+10.89
	XII.	115.3	96.8	+18.5	+97.0	+8.72
1947	I.	86.8	74.5	+12.3	+109.3	+7.63
	II.	115.1	99.4	+15.7	+125.0	+7.32
	III.	90.5	100.2	—9.7	+115.3	—5.09
	IV.	98.0	92.8	+5.2	+120.5	+2.73
	V.	144.4	134.3	+10.1	+130.6	+3.62
	VI.	105.4	111.1	—5.7	+124.9	—2.63
	VII.	96.0	87.6	+8.4	+133.3	+4.58
	VIII.	127.3	102.0	+25.3	+158.6	+11.03
	IX.	110.0	112.0	—2.0	+156.6	—0.90
	X.	93.5	109.2	—15.7	+140.9	—7.75
	XI.	70.4	74.1	—3.7	+137.2	—2.56
	XII.	84.1	81.7	+2.4	+139.6	+1.45
1948	I.	72.2	67.5	+4.7	+144.3	+3.36
	II.	63.3	53.6	+9.7	+154.0	+8.30
	III.	67.4	56.4	+11.0	+165.0	+8.89
	IV.	140.9	129.7	+11.2	+176.2	+4.14
	V.	147.5	108.5	+39.0	+215.2	+15.23
	VI.	107.8	111.3	—3.5	+211.7	—1.60
	VII.	95.7	101.1	—5.4	+206.3	—2.74
	VIII.	110.6	102.3	+8.3	+214.6	+3.90
	IX.	93.0	94.0	—1.0	+213.6	—0.53
	X.	85.2	95.9	—10.7	+202.9	—5.91
	XI.	62.4	59.6	+2.8	+205.7	+2.30
	XII.	103.7	86.0	+17.7	+223.4	+9.33
1949	I.	65.6	70.8	—5.2	+218.2	—3.81
	II.	114.7	129.0	—14.3	+203.9	—5.87
	III.	81.4	113.2	—31.8	+172.1	—16.34
	IV.	89.6	98.4	—8.8	+163.3	—4.68
	V.	78.4	80.4	—2.0	+161.3	—1.26
	VI.	71.0	80.4	—9.4	+151.9	—6.21
	VII.	77.5	67.5	+10.0	+161.9	+6.90
	VIII.	79.7	110.0	—30.3	+131.6	—15.97
	IX.	126.0	121.7	+4.3	+135.9	+1.74
	X.	109.5	114.0	—4.5	+131.4	—2.01
	XI.	108.9	117.3	—8.4	+123.0	—3.71
	XII.	89.2	97.7	—8.5	+114.5	—4.55
1950	I.	75.7	115.2	—39.5	+75.0	—20.69
	II.	67.9	68.6	—0.7	+74.3	—0.51
	III.	82.1	76.6	+5.5	+79.8	+3.47
	IV.	93.6	95.0	—1.4	+78.4	—0.74
	V.	89.6	110.1	—20.5	+57.9	—10.27
	VI.	67.4	73.1	—5.7	+52.2	—4.06
	VII.	68.7	75.2	—6.5	+45.7	—4.52
	VIII.	68.5	57.7	+10.8	+56.5	+8.56
	IX.	36.4	40.3	—3.9	+52.6	—5.08
	X.	41.9	34.8	+7.1	+59.7	+9.26
	XI.	30.0	38.5	—8.5	+51.2	—12.41
	XII.	27.3	46.3	—19.0	+32.2	—23.82
1951	I.	50.0	46.6	+3.4	+35.6	+3.52
	II.	47.4	40.4	+7.0	+42.6	+7.97
	III.	26.0	35.1	—9.1	+33.5	—14.89
	IV.	65.1	55.4	+9.7	+43.2	+8.06
	V.	33.4	40.1	—6.7	+36.5	—9.12
	VI.	71.5	75.5	—4.0	+32.5	—2.72
	VII.	52.1	42.9	+9.2	+41.7	+9.68
	VIII.	41.2	45.0	—3.8	+37.9	—4.41
	IX.	73.7	52.6	+21.1	+59.0	+16.71
	X.	40.0	36.3	+3.7	+62.7	+4.85
	XI.	29.3	36.0	—6.7	+56.0	—10.26
	XII.	28.1	35.0	—6.9	+49.1	—10.94
1952	I.	21.2	24.7	—3.5	+45.6	—7.63
	II.	6.3	16.2	—9.9	+35.7	—44.00
	III.	16.5	14.8	+1.7	+37.4	+5.43
	IV.	15.1	26.6	—11.5	+25.9	—27.58
	V.	10.0	23.4	—13.4	+12.5	—40.12
	VI.	24.5	24.8	—0.3	+12.2	—0.61
	VII.	16.0	17.4	—1.4	+10.8	—4.19
	VIII.	40.7	30.2	+10.5	+21.3	+14.81
	IX.	14.5	15.5	—1.0	+20.3	—3.33
	X.	15.4	9.9	+5.5	+25.8	+21.74
	XI.	17.3	15.4	+1.9	+27.7	+5.81
	XII.	21.4	13.6	+7.8	+35.5	+22.29
1953	I.	19.0	26.6	—7.6	+27.9	—16.67
	II.	2.8	2.4	+0.4	+28.3	+7.69
	III.	9.6	2.1	+7.5	+35.8	+64.10
	IV.	23.8	13.5	+10.3	+46.1	+27.61
	V.	4.8	14.0	—9.2	+36.9	—48.94
	VI.	14.4	13.3	+1.1	+38.0	+3.97
	VII.	5.6	4.9	+0.7	+38.7	+6.67
	VIII.	17.6	16.8	+0.8	+39.5	+3.28
	IX.	14.2	10.5	+3.7	+43.2	+14.98
	X.	3.5	4.8	—1.3	+41.9	—15.66
	XI.	1.9	0.0	+1.9	+43.8	+100.00
	XII.	1.6	1.2	+0.4	+44.2	+14.29
1954	I.	0.0	0.0	0.0	+44.2	0.00
	II.	0.0	0.0	0.0	+44.2	0.00
	III.	6.3	9.3	—3.0	+41.2	—19.23
	IV.	2.1	0.0	+2.1	+43.3	+100.00
	V.	0.6	0.0	+0.6	+43.9	+100.00
	VI.	0.0	0.0	0.0	+43.9	0.00
	VII.	1.0	4.7	—3.7	+40.2	—64.91
	VIII.	5.0	7.9	—2.9	+37.3	—22.49
	IX.	0.5	0.6	—0.1	+37.2	—9.09
	X.	6.2	2.8	+3.4	+40.6	+37.78
	XI.	2.1	5.4	—3.3	+37.3	—44.00
	XII.	9.7	6.0	+3.7	+41.0	+23.57
1955	I.	29.3	13.9	+15.4	+56.4	+35.65
	II.	13.2	15.1	—1.9	+54.5	—6.71
	III.	1.4	8.6	—7.2	+47.3	—72.00
	IV.	7.9	10.2	—2.3	+45.0	—12.71
	V.	16.3	9.4	+6.9	+51.9	+26.85
	VI.	18.8	11.0	+7.8	+59.7	+26.17
	VII.	25.2	11.2	+14.0	+73.7	+38.46
	VIII.	22.9	27.6	—4.7	+69.0	—9.31

Continuation Table 1

Year	Month	E	W	E — W	Σ(E — W)	$\frac{E - W}{E + W}$ %
	IX.	40.7	29.7	+11.0	+80.0	+15.63
	X.	38.8	32.0	+6.8	+86.8	+9.60
	XI.	55.7	51.5	+4.2	+91.0	+3.92
	XII.	44.4	33.9	+10.5	+101.5	+13.41
1956	I.	45.4	40.6	+4.8	+106.3	+5.58
	II.	95.0	67.1	+27.9	+134.2	+17.21
	III.	90.0	74.4	+15.6	+149.8	+9.49
	IV.	73.6	57.4	+16.2	+166.0	+12.37
	V.	78.9	82.5	—3.6	+162.4	—2.23
	VI.	76.0	56.6	+19.4	+181.8	+14.63
	VII.	72.0	69.3	+2.7	+184.5	+1.91
	VIII.	94.4	65.5	+28.9	+213.4	+18.07
	IX.	101.6	95.9	+5.7	+219.1	+2.89
	X.	58.0	111.2	—53.2	+165.9	—31.44
	XI.	85.3	101.4	—16.1	+149.8	—8.62
	XII.	115.8	101.2	+14.6	+164.4	+6.73
1957	I.	92.0	102.4	—10.4	+154.0	—5.35
	II.	73.9	62.6	+11.3	+165.3	+8.28
	III.	109.1	81.0	+28.1	+193.4	+14.78
	IV.	92.1	104.7	—12.6	+180.8	—6.40
	V.	88.3	113.5	—25.2	+155.6	—12.49
	VI.	124.6	107.8	+16.8	+172.4	+7.23
	VII.	117.8	123.4	—5.6	+166.8	—2.32
	VIII.	106.1	95.6	+10.5	+177.3	+5.21
	IX.	161.0	143.5	+17.5	+194.8	+5.75
	X.	215.8	191.4	+24.4	+219.2	+5.99
	XI.	127.5	149.6	—22.1	+197.1	—7.98
	XII.	181.0	147.6	+33.4	+230.5	+10.16
1958	I.	108.7	115.5	—6.8	+223.7	—3.03
	II.	70.2	108.6	—38.4	+185.3	—21.48
	III.	133.8	102.7	+31.1	+216.4	+13.15
	IV.	131.4	99.7	+31.7	+248.1	+13.72
	V.	126.5	152.7	—26.2	+221.9	—9.38
	VI.	144.4	91.8	+52.6	+274.5	+22.27
	VII.	143.7	150.6	—6.9	+267.6	—2.34
	VIII.	127.0	158.3	—31.3	+236.3	—10.97
	IX.	177.1	153.4	+23.7	+260.0	+7.17
	X.	130.8	110.2	+20.6	+280.6	+8.55
	XI.	125.4	122.1	+3.3	+283.9	+1.33
	XII.	129.3	123.1	+6.2	+290.1	+2.46
1959	I.	155.9	116.5	+39.4	+329.5	+14.46
	II.	90.7	78.9	+11.8	+341.3	+6.96
	III.	152.1	139.8	+12.3	+353.6	+4.21
	IV.	108.8	153.6	—44.8	+308.8	—17.07
	V.	143.3	125.2	+18.3	+327.1	+6.82
	VI.	130.5	120.7	+9.8	+336.9	+3.90
	VII.	115.7	88.9	+26.8	+363.7	+13.10
	VIII.	146.5	128.1	+18.4	+382.1	+6.70
	IX.	80.7	92.5	—11.8	+370.3	—6.81
	X.	75.8	63.4	+12.4	+382.7	+8.91
	XI.	86.0	71.6	+14.4	+397.1	+9.14
	XII.	74.3	81.3	—7.0	+390.1	—4.50
1960	I.	88.7	66.8	+21.9	+412.0	+14.08
	II.	53.1	60.2	—7.1	+404.9	—6.27
	III.	70.9	63.9	+7.0	+411.9	+5.19
	IV.	83.1	80.8	+2.3	+414.2	+1.40
	V.	88.6	94.2	—5.6	+408.6	—3.06
	VI.	97.7	95.8	+1.9	+410.5	+0.98
	VII.	82.9	90.4	—7.5	+403.0	—4.33
	VIII.	71.4	102.5	—31.1	+371.9	—17.88
	IX.	83.2	90.6	—7.4	+364.5	—4.26
	X.	63.0	42.6	+20.4	+384.9	+19.32

Year	Month	E	W	E — W	Σ(E — W)	$\frac{E - W}{E + W}$ %
	XI.	56.7	59.9	—3.2	+381.7	—2.74
	XII.	53.7	60.7	—7.0	+374.7	—6.12
1961	I.	29.7	26.4	+3.3	+378.0	+5.88
	II.	51.8	50.0	+1.8	+379.8	+1.77
	III.	41.8	33.2	+8.6	+388.4	+11.47
	IV.	52.4	58.6	—6.2	+382.2	—5.59
	V.	31.0	46.8	—15.8	+366.4	—20.31
	VI.	64.1	83.2	—19.1	+347.3	—12.97
	VII.	46.1	52.7	—6.6	+340.7	—6.68
	VIII.	32.9	37.5	—4.6	+336.1	—6.53
	IX.	38.4	48.3	—9.9	+326.2	—11.42
	X.	17.0	35.6	—18.6	+307.6	—35.36
	XI.	15.4	20.8	—5.4	+302.2	—14.92
	XII.	19.5	23.2	—3.7	+298.5	—8.67
1962	I.	18.4	6.8	+11.6	+310.1	+46.03
	II.	30.1	35.4	—5.3	+304.8	—8.09
	III.	19.4	27.4	—8.0	+296.8	—17.09
	IV.	23.2	37.6	—14.4	+282.4	—23.68
	V.	23.9	24.1	—0.2	+282.2	—0.42
	VI.	35.3	21.2	+14.1	+296.3	+24.96
	VII.	10.0	13.4	—3.4	+292.9	—14.53
	VIII.	10.6	13.3	—2.7	+290.2	—11.30
	IX.	29.0	38.3	—9.3	+280.9	—13.82
	X.	34.9	20.3	+14.6	+295.5	+26.45
	XI.	8.0	8.8	—0.8	+294.7	—4.76
	XII.	11.0	21.6	—10.6	+284.1	—32.52
1963	I.	2.6	8.6	—6.0	+278.1	—53.57
	II.	12.5	13.1	—0.6	+277.5	—2.34
	III.	11.2	3.8	+7.4	+284.9	+49.33
	IV.	9.7	20.1	—10.4	+274.5	—34.90
	V.	25.3	27.2	—1.9	+272.6	—3.62
	VI.	22.5	19.7	+2.8	+275.4	+6.64
	VII.	9.4	13.3	—3.9	+271.5	—17.18
	VIII.	16.8	21.6	—4.8	+266.7	—12.50
	IX.	27.5	30.0	—2.5	+264.2	—4.35
	X.	17.7	24.3	—6.6	+257.6	—15.71
	XI.	19.0	21.1	—2.1	+255.5	—5.24
	XII.	11.7	9.7	+2.0	+257.5	+9.35
1964	I.	16.9	11.2	+5.7	+263.2	+20.28
	II.	24.5	24.9	—0.4	+262.8	—0.81
	III.	11.4	17.5	—6.1	+256.7	—21.11
	IV.	16.8	11.4	+5.4	+262.1	+19.15
	V.	11.0	16.7	—5.7	+256.4	—20.58
	VI.	13.6	11.8	+1.8	+258.2	+7.09
	VII.	3.6	1.9	+1.7	+259.9	+30.91
	VIII.	4.2	10.8	—6.6	+253.3	—44.00
	IX.	2.8	2.0	+0.8	+254.1	+16.67
	X.	3.8	8.1	—4.3	+249.8	—36.13
	XI.	2.1	6.5	—4.4	+245.4	—51.16
	XII.	15.4	9.9	+5.5	+250.9	+21.74
1965	I.	11.3	14.4	—3.1	+247.8	—12.06
	II.	9.2	12.0	—2.8	+245.0	—13.21
	III.	13.6	9.2	+4.4	+249.4	+19.30
	IV.	6.3	6.2	+0.1	+249.5	+8.00
	V.	9.8	7.9	+1.9	+251.4	+10.73
	VI.	7.7	7.7	0.0	+251.4	0.00
	VII.	15.3	17.8	—2.5	+248.9	—7.55
	VIII.	9.1	6.3	+2.8	+251.7	+18.18
	IX.	12.4	13.7	—1.3	+250.4	—4.98
	X.	12.7	15.0	—2.3	+248.1	—8.30
	XI.	8.4	17.9	—9.5	+238.6	—36.12
	XII.	11.6	15.1	—3.5	+235.1	—13.11

Table II

Smoothed monthly relative numbers in the eastern and western half of the solar disc and their asymmetry—Skalnaté Pleso

Year	Month	E	W	E — W	Σ(E — W)	$\frac{E - W}{E + W}$ %
1945	IV.	20.1	17.7	+2.4	+2.4	+6.35
	V.	22.1	19.7	+2.4	+4.8	+5.74
	VI.	22.5	19.9	+2.6	+7.4	+6.13
	VII.	23.5	20.2	+3.3	+10.7	+7.55
	VIII.	26.3	22.8	+3.5	+14.2	+7.13
	IX.	29.7	26.5	+3.2	+17.4	+5.69
	X.	32.8	29.8	+3.0	+20.4	+4.79
	XI.	35.8	32.9	+2.9	+23.3	+4.22
	XII.	38.7	35.8	+2.9	+26.2	+3.89
1946	I.	43.0	38.5	+4.5	+30.7	+5.52
	II.	48.5	44.7	+3.8	+34.5	+4.08
	III.	52.9	49.8	+3.1	+37.6	+3.02
	IV.	55.8	53.4	+2.4	+40.0	+2.20
	V.	60.1	56.9	+3.2	+43.2	+2.74
	VI.	67.6	62.8	+4.8	+48.0	+3.68
	VII.	73.7	68.0	+5.7	+53.7	+4.02
	VIII.	78.4	71.9	+6.5	+60.2	+4.32
	IX.	82.5	75.8	+6.7	+66.9	+4.23
	X.	85.7	79.5	+6.2	+73.1	+3.75
	XI.	91.0	83.9	+7.1	+80.2	+4.06
	XII.	96.6	89.2	+7.4	+87.6	+3.98
1947	I.	98.3	91.7	+6.6	+94.2	+3.47
	II.	99.9	92.7	+7.2	+101.4	+3.74
	III.	103.5	95.3	+8.2	+109.6	+4.12
	IV.	106.3	98.7	+7.6	+117.2	+3.71
	V.	105.9	100.0	+5.9	+123.1	+2.87
	VI.	103.1	98.9	+4.2	+127.3	+2.08
	VII.	101.2	97.9	+3.3	+130.6	+1.66
	VIII.	98.4	95.7	+2.7	+133.3	+1.39
	IX.	95.3	92.0	+3.3	+136.6	+1.76
	X.	96.0	91.7	+4.3	+141.0	+2.34
	XI.	98.0	92.2	+5.8	+146.8	+3.05
	XII.	98.3	91.1	+7.2	+154.0	+3.80
1948	I.	98.4	91.7	+6.7	+160.7	+3.52
	II.	97.7	92.3	+5.4	+166.1	+2.84
	III.	96.2	91.5	+4.7	+170.8	+2.50
	IV.	95.2	90.2	+5.0	+175.8	+2.70
	V.	94.5	89.1	+5.4	+181.2	+2.44
	VI.	95.0	88.7	+6.3	+187.5	+3.43
	VII.	95.5	89.0	+6.5	+194.0	+3.52
	VIII.	97.4	92.2	+5.2	+199.2	+2.74
	IX.	100.1	97.8	+2.3	+201.5	+1.26
	X.	98.6	98.8	—0.2	+201.3	—0.10
	XI.	93.5	96.3	—2.8	+198.5	—1.58
	XII.	89.1	93.9	—4.8	+193.7	—2.62
1949	I.	86.8	91.2	—4.4	+189.3	—2.47
	II.	81.8	90.0	—8.2	+184.1	—2.97
	III.	83.6	91.6	—8.0	+176.1	—4.57
	IV.	87.3	93.5	—6.2	+169.9	—3.43
	V.	90.2	96.7	—6.5	+163.4	—3.48
	VI.	91.6	99.5	—7.9	+155.5	—4.13
	VII.	91.4	101.9	—10.5	+145.0	—2.43
	VIII.	89.8	101.2	—11.4	+133.6	—5.97
	IX.	87.9	97.2	—9.3	+124.3	—5.02
	X.	88.1	95.5	—7.4	+116.9	—4.03
	XI.	88.8	96.6	—7.8	+109.1	—4.21
	XII.	89.1	97.5	—8.4	+100.7	—4.50
1950	I.	88.6	97.6	—9.0	+91.7	—4.83
	II.	87.7	95.7	—8.0	+83.7	—4.36
	III.	83.5	90.1	—6.6	+77.1	—3.80
	IV.	77.0	83.4	—6.4	+70.7	—3.99
	V.	70.9	76.9	—6.0	+64.7	—4.06
	VI.	65.0	71.4	—6.4	+58.3	—4.69
	VII.	61.4	66.4	—5.0	+53.3	—3.91
	VIII.	59.4	62.4	—3.0	+50.3	—2.46
	IX.	56.2	59.5	—3.3	+47.0	—2.85
	X.	52.7	56.1	—3.4	+43.6	—3.13
	XI.	49.2	51.5	—2.3	+41.3	—2.28
	XII.	47.0	48.7	—1.7	+39.6	—1.78
1951	I.	46.5	47.5	—1.0	+38.6	—1.06
	II.	44.7	45.6	—0.9	+37.7	—0.97
	III.	45.0	45.6	—0.6	+37.1	—0.66
	IV.	46.6	46.2	+0.4	+37.5	+0.43
	V.	46.4	46.1	+0.3	+37.8	+0.32
	VI.	46.5	45.5	+1.0	+38.8	+1.08
	VII.	45.3	44.2	+1.1	+39.9	+1.23
	VIII.	42.4	42.2	+0.2	+40.1	+0.24
	IX.	40.3	40.4	—0.1	+40.0	—0.12
	X.	37.8	38.3	—0.5	+39.5	—0.66
	XI.	34.7	36.4	—1.7	+37.8	—2.39
	XII.	31.8	33.6	—1.8	+36.0	—2.75
1952	I.	28.3	30.5	—2.2	+33.8	—3.74
	II.	26.8	28.8	—2.0	+31.8	—3.59
	III.	24.3	26.6	—2.3	+29.5	—4.52
	IV.	20.8	24.0	—3.2	+26.3	—7.14
	V.	19.3	22.0	—2.7	+23.6	—6.53
	VI.	18.5	20.3	—1.8	+21.8	—4.64
	VII.	18.2	19.5	—1.3	+20.5	—3.45
	VIII.	17.9	19.0	—1.1	+19.4	—2.98
	IX.	17.5	17.9	—0.4	+19.0	—1.13
	X.	17.6	16.8	+0.8	+19.8	+2.36
	XI.	17.7	15.8	+1.9	+21.7	+5.67
	XII.	17.1	15.0	+2.1	+23.8	+6.54
1953	I.	16.2	14.0	+2.2	+26.8	+7.28
	II.	14.8	12.9	+1.9	+27.9	+6.86
	III.	13.8	12.1	+1.7	+29.6	+6.56
	IV.	13.3	11.7	+1.6	+31.2	+6.40
	V.	12.2	10.9	+1.3	+32.5	+5.63
	VI.	10.7	9.7	+1.0	+33.5	+4.90
	VII.	9.1	8.1	+1.0	+34.5	+5.81
	VIII.	8.2	6.9	+1.3	+35.8	+8.61
	IX.	7.9	7.1	+0.8	+36.6	+5.33
	X.	6.9	6.8	+0.1	+36.7	+0.73
	XI.	5.8	5.7	+0.1	+36.8	+0.87
	XII.	5.1	4.5	+0.6	+37.4	+6.25
1954	I.	4.3	4.0	+0.3	+37.7	+3.61
	II.	3.5	3.6	—0.1	+37.6	—1.41
	III.	2.4	2.8	—0.4	+37.2	—7.69
	IV.	2.0	2.3	—0.3	+36.9	—6.98
	V.	2.1	2.4	—0.3	+36.6	—6.67
	VI.	2.5	2.9	—0.4	+36.2	—7.41
	VII.	4.0	3.6	+0.4	+36.6	+5.26
	VIII.	5.8	4.8	+1.0	+37.6	+9.43
	IX.	6.1	5.4	+0.7	+38.3	+6.09
	X.	6.2	5.8	+0.4	+38.7	+3.33
	XI.	7.1	6.7	+0.4	+39.1	+2.90
	XII.	8.5	7.5	+1.0	+40.1	+6.25
1955	I.	10.3	8.2	+2.1	+42.2	+11.35
	II.	12.0	9.3	+2.7	+44.9	+12.68
	III.	14.5	11.4	+3.1	+48.0	+11.97
	IV.	17.5	13.8	+3.7	+51.7	+11.82
	V.	21.1	16.9	+4.2	+55.9	+11.05
	VI.	24.8	20.0	+4.8	+60.7	+10.71
	VII.	26.9	22.3	+4.6	+65.3	+9.35
	VIII.	31.0	25.6	+5.4	+70.7	+9.54
	IX.	38.1	30.5	+7.6	+78.3	+11.09
	X.	44.5	35.2	+9.3	+87.6	+11.67
	XI.	49.8	40.0	+9.8	+97.2	+10.67
	XII.	54.8	45.1	+9.7	+106.9	+9.71
1956	I.	59.2	49.5	+9.7	+116.6	+8.92
	II.	64.1	53.5	+10.6	+127.2	+9.01

Year	Month	E	W	E — W	Σ(E — W)	$\frac{E-W}{E+W}$ %
	III.	69.6	57.8	+11.8	+139.0	+9.26
	IV.	73.0	63.9	+9.1	+148.1	+6.64
	V.	75.0	69.2	+5.8	+153.9	+4.02
	VI.	79.2	74.1	+5.1	+159.0	+3.33
	VII.	84.1	79.5	+4.6	+163.6	+2.81
	VIII.	85.2	81.9	+3.3	+166.9	+1.97
	IX.	85.1	82.0	+3.1	+170.0	+1.86
	X.	86.7	84.2	+2.5	+172.5	+1.46
	XI.	87.8	87.5	+0.3	+172.8	+0.17
	XII.	90.2	90.9	—0.7	+172.1	—0.39
1957	I.	94.2	95.3	—1.1	+171.0	—0.58
	II.	96.6	98.8	—2.2	+168.8	—1.13
	III.	99.5	102.0	—2.5	+166.3	—1.24
	IV.	108.6	107.4	+1.2	+167.5	+0.56
	V.	116.9	112.7	+4.2	+171.7	+1.83
	VI.	121.4	116.7	+4.7	+176.4	+1.97
	VII.	124.8	119.1	+5.7	+182.1	+2.34
	VIII.	125.3	121.6	+3.7	+185.8	+1.50
	IX.	126.2	124.4	+1.8	+187.6	+0.72
	X.	128.9	125.1	+3.8	+191.4	+1.50
	XI.	132.1	126.5	+5.6	+197.0	+2.17
	XII.	134.5	127.5	+7.0	+204.0	+2.57
1958	I.	136.4	128.0	+8.4	+212.4	+3.18
	II.	138.4	131.7	+6.7	+219.1	+2.48
	III.	139.9	134.7	+5.2	+224.3	+1.89
	IV.	137.0	131.8	+5.2	+229.5	+1.93
	V.	133.4	127.2	+6.2	+235.7	+2.38
	VI.	131.2	125.0	+6.2	+241.9	+2.42
	VII.	131.0	124.1	+6.9	+248.8	+2.70
	VIII.	133.8	122.9	+10.9	+259.7	+4.25
	IX.	135.4	123.2	+12.2	+271.9	+4.72
	X.	135.2	127.0	+8.2	+280.1	+3.13
	XI.	135.0	128.1	+6.9	+287.0	+2.62
	XII.	135.1	128.1	+7.0	+294.0	+2.66
1959	I.	133.4	126.8	+6.6	+300.6	+2.54
	II.	133.0	123.0	+10.0	+310.6	+3.91
	III.	129.8	119.2	+10.6	+321.2	+4.26
	IV.	123.5	115.1	+8.4	+329.6	+3.52
	V.	119.6	111.0	+8.6	+338.2	+3.73
	VI.	115.7	107.2	+8.5	+346.7	+3.81
	VII.	110.6	103.4	+7.2	+353.9	+3.36
	VIII.	106.2	100.1	+6.1	+360.0	+2.96
	IX.	101.2	96.2	+5.0	+365.0	+2.53
	X.	96.8	90.0	+6.8	+371.8	+3.64
	XI.	93.4	85.7	+7.7	+379.5	+4.30
	XII.	89.8	83.4	+6.4	+385.9	+3.70
1960	I.	87.1	82.4	+4.7	+390.6	+2.77
	II.	82.6	81.4	+1.2	+391.8	+0.73
	III.	79.5	80.2	—0.7	+391.1	—0.44
	IV.	79.1	79.3	—0.2	+390.9	—0.13
	V.	77.4	77.9	—0.5	+390.4	—0.32
	VI.	75.3	76.6	—1.3	+389.1	—0.86
	VII.	72.0	74.0	—2.0	+387.1	—1.37
	VIII.	69.4	71.9	—2.5	+384.6	—1.77
	IX.	68.2	70.2	—2.0	+382.6	—1.44
	X.	65.7	68.0	—2.3	+380.3	—1.72

Year	Month	E	W	E — W	Σ(E — W)	$\frac{E-W}{E+W}$ %
	XI.	62.0	65.1	—3.1	+377.2	—2.44
	XII.	58.2	62.6	—4.4	+372.8	—3.64
1961	I.	55.3	60.5	—5.2	+367.6	—4.49
	II.	52.1	56.2	—4.1	+353.5	—3.79
	III.	48.7	51.8	—3.1	+360.4	—3.08
	IV.	44.9	49.7	—4.8	+355.6	—5.07
	V.	41.2	47.8	—6.6	+349.0	—7.42
	VI.	38.1	44.6	—6.5	+342.5	—7.86
	VII.	36.2	42.2	—6.0	+336.5	—7.65
	VIII.	34.8	40.8	—6.0	+330.5	—7.94
	IX.	33.0	39.9	—6.9	+323.6	—9.47
	X.	30.8	38.8	—8.0	+315.6	—11.49
	XI.	29.3	37.0	—7.7	+307.9	—11.61
	XII.	27.8	33.5	—5.7	+302.2	—9.30
1962	I.	25.1	29.2	—4.1	+289.1	—7.55
	II.	22.7	26.6	—3.9	+294.2	—7.91
	III.	21.4	25.2	—3.8	+290.4	—8.15
	IV.	21.7	24.1	—2.4	+288.0	—5.24
	V.	22.2	23.0	—0.8	+287.2	—1.77
	VI.	21.5	22.4	—0.9	+286.3	—2.05
	VII.	20.5	22.4	—1.9	+284.4	—4.43
	VIII.	19.1	21.5	—2.4	+282.0	—5.91
	IX.	18.0	19.7	—1.7	+280.3	—4.51
	X.	17.1	17.9	—0.8	+279.5	—2.29
	XI.	16.6	17.3	—0.7	+278.8	—2.06
	XII.	16.1	17.4	—1.3	+277.5	—3.88
1963	I.	15.6	17.3	—1.7	+275.8	—5.17
	II.	15.8	17.7	—1.9	+273.9	—5.67
	III.	16.0	17.7	—1.7	+272.2	—5.04
	IV.	15.2	17.5	—2.3	+269.9	—7.03
	V.	15.0	18.2	—3.2	+266.7	—9.64
	VI.	15.5	18.2	—2.7	+254.0	—8.01
	VII.	16.1	17.8	—1.7	+262.3	—5.01
	VIII.	17.2	18.4	—1.2	+261.1	—3.37
	IX.	17.7	19.5	—1.8	+259.3	—4.84
	X.	18.0	19.7	—1.7	+257.6	—4.51
	XI.	17.7	18.9	—1.2	+256.4	—3.28
	XII.	16.7	18.1	—1.4	+256.0	—4.02
1964	I.	16.1	17.3	—1.2	+253.8	—3.59
	II.	15.4	16.4	—1.0	+252.8	—3.14
	III.	13.8	14.8	—1.0	+251.8	—3.50
	IV.	12.2	12.9	—0.7	+251.1	—2.79
	V.	10.9	11.7	—0.8	+250.3	—3.54
	VI.	10.4	11.1	—0.7	+249.6	—3.26
	VII.	10.3	11.2	—0.9	+248.7	—4.19
	VIII.	9.4	10.8	—1.4	+247.3	—6.93
	IX.	8.9	9.9	—1.0	+246.3	—5.32
	X.	8.5	9.3	—0.8	+245.5	—4.49
	XI.	8.0	8.8	—0.8	+244.7	—4.76
	XII.	7.7	8.2	—0.5	+244.2	—3.14
1965	I.	8.0	8.7	—0.7	+243.5	—4.19
	II.	8.7	9.2	—0.5	+243.0	—2.79
	III.	9.3	9.5	—0.2	+242.8	—1.06
	IV.	10.0	10.3	—0.3	+242.5	—1.48
	V.	10.7	11.0	—0.3	+242.2	—1.38
	VI.	10.8	11.7	—0.9	+241.3	—4.00

Discussion of the asymmetry determined

The numerical results of the distribution of the Wolf number between the eastern and western half of the solar disc lead to the following conclusions:

1. The prevalence of the eastern half of the solar disc, that is positive asymmetry, is not systematical for the Wolf number, as found at Skalnaté Pleso, since it changes to negative asymmetry after a certain time.

2. The prevalence of both the eastern and wes-

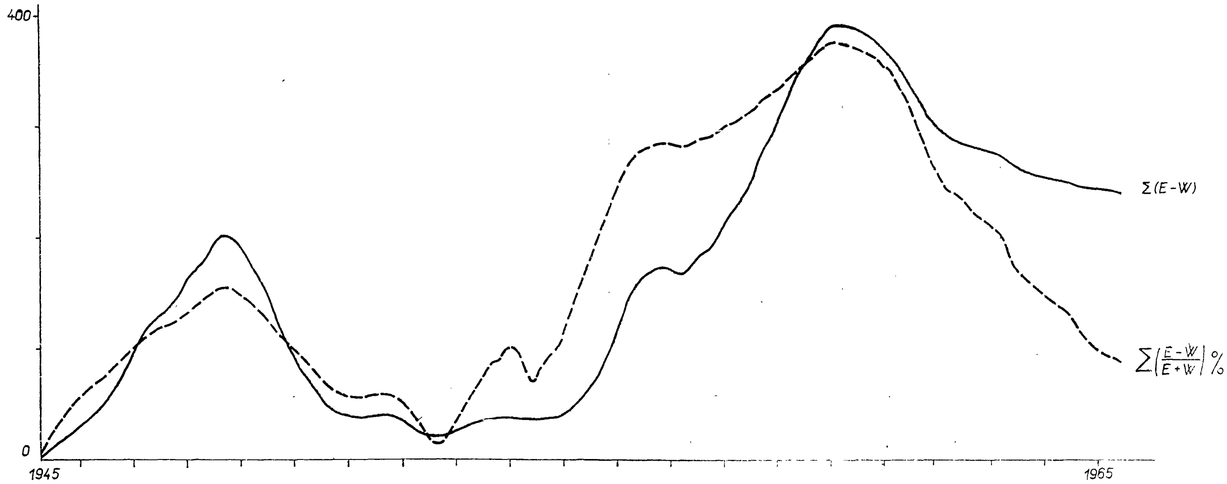

Figure 2. Variations in the cumulative sums of total (——) and relative (- - - -) asymmetry in the smoothed out monthly Wolf numbers—Skalnaté Pleso.

Table III

The number of months with positive (= E) and negative (= W) asymmetry for different periods—Skalnaté Pleso

Period	Number of months with asymmetry + (= E)	Number of months with asymmetry — (= W)	E—W	$\frac{E-W}{E+W}$ %
Observed monthly relative numbers				
X. 1944— V. 1948	31	13	+18	+41%
VI. 1948— IV. 1955	34	49	—15	—18
V. 1955— IV. 1960	42	18	+24	+40
V. 1960—VII. 1966	22	52	—30	—41
Smoothed monthly relative numbers				
V. 1945— IX. 1948	42	0	+42	+100
X. 1948— IX. 1952	5	42	—37	— 79
X. 1952— II. 1960	70	9	+61	+ 77
III. 1960— I. 1966	0	71	—71	—100

tern half of the solar disc over a certain relatively long period is systematical: both positive and negative asymmetry in certain periods occur more frequently than would accidentally occur one out of two possible alternatives.

3. East-west asymmetry variations between positive and negative values appear not to be accidental. Two cases, that is the 18th and 19th cycle, certainly cannot lead to a definitive conclusion, yet it is worth noting that asymmetry roughly changes in the periods subsequent minimum and maximum solar activity. Or, in other words, positive asymmetry is more frequent on the ascending branch of the 11-year cycle and at the time of high solar activity, while negative asymmetry is more frequent on the descending branch and at the time of low solar activity. Letfus (1959) obtained a similar result for chromospheric flares.

4. Knowing that asymmetry is nor exclusively positive, but that it varies between positive and negative values and that these variations are not accidental, we have to give up certain interpretations of positive asymmetry, such as the inclination of the axis or the unfavourable influence of the Earth which ban negative asymmetry, except it were a local error (Link for the corona, 1957). The asymmetry variations, however, call for explanation not only of the asymmetry itself, both positive and negative, but also of the cause of these variations. This, evidently, adds to the complexity of the asymmetry problem.

5. First, however, it will have to be determined whether the variations in asymmetry are:

a) a phenomenom real on the Sun itself,

b) a phenomenon only due to certain terrestrial conditions,

c) a local error, in the given case an error at Skalnaté Pleso.

Ad a) If the asymmetry variations in a certain rhythm with the 11-year cycle of solar activity are a real phenomenon on the Sun itself, this phenomenon must be observed by all stations, in the main, however, in the supplemented observational series. In this case, the asymmetry would be a virtual characteristic of the 11-year cycle.

Ad b) If the asymmetry is only due to a terrestrial phenomenon, such as poorer observational conditions after the transit of the active region through the central meridian, or pending observation, positive activity ought to be lower or even non existent in observational series put together by a number of stations. This, naturally, means that the terrestrial effect responsible for apparent asymmetry must depend in a way on solar activity.

Ad c) If the asymmetry variations observed are only a local error of Skalnaté Pleso, other stations, and especially the supplemented observational series, naturally cannot record such asymmetry.

Asymmetry in the number of groups

In order to determine which of these three possibilities is responsible for the asymmetry observed at Skalnaté Pleso, we examined the asymmetry in groups not only as found at Skalnaté Pleso, but also as found by two other independent stations: Uccle and Tokyo. The material published by the Eidgenössische Sternwarte, Zurich, permits to compare the asymmetry reported by one station with that given in the supplemented observational series.

The east-west asymmetry in groups as given by these stations for each year is listed in Tabs. IV through VII. Tab. VIII gives both the relative and total asymmetry for the stations in question all over the common period.

Table IV

Asymmetry of groups—Skalnaté Pleso

Year	E + W	E — W	Σ(E — W)	$\frac{E - W}{E + W}$ %
1945	912	+54	+54	+5.9%
1946	2125	+39	+93	+1.8
1947	2877	—29	+64	—1.0
1948	2557	+93	+157	+3.6
1949	2499	—71	+86	—2.8
1950	1841	—69	+17	—3.7
1951	1299	+21	+38	+1.6
1952	546	—20	+18	—3.7
1953	299	—1	+17	—0.3
1954	75	—7	+10	—9.3
1955	571	+61	+71	+10.7
1956	1856	+112	+183	+6.0
1957	2183	+121	+304	+5.5
1958	2638	+72	+376	+2.7
1959	2531	+191	+567	+7.5
1960	2269	+19	+586	+0.8
1961	1123	—71	+515	—6.3
1962	491	+25	+540	+5.1
1963	485	—19	+521	—3.9
1964	379	—3	+518	—0.8
1965	243	+7	+525	+2.9
Total	29799	+525		+1.8

The total and relative asymmetry for the period in common of the four stations in question, that is Skalnaté Pleso, Tokyo, Uccle and Zurich, permit

Table V

Asymmetry of groups—Tokyo

Year	E + W	E — W	Σ(E — W)	$\frac{E - W}{E + W}$ %
1950	1741	—3	—3	—0.2%
1951	1369	—1	—4	—0.1
1952	711	—13	—17	—1.8
1953	306	+12	—5	+3.9
1954	134	—2	—7	—1.5
1955	920	—24	—31	—2.6
1956	2410	+52	+21	+2.2
1957	3294	+82	+103	+2.5
1958	3302	—4	+99	—0.1
1959	2300	+52	+151	+2.3
1960	2259	+69	+220	+3.1
1961	1146	+6	+226	+0.5
1962	662	+2	+228	+0.3
1963	553	+23	+251	+4.2
1964	221	—17	+234	—7.7
Total	21328	+234		+1.1

Table VI

Asymmetry of groups—Uccle

Year	E + W	E — W	Σ(E — W)	$\frac{E - W}{E + W}$ %
1950	2232	—200	—200	—9.0
1951	1472	—94	—294	—6.4
1952	762	—42	—336	—5.5
1953	259	+29	—307	+11.2
1954	104	—4	—311	—3.8
1955	482	+8	—303	+1.7
1956	2140	+8	—295	+0.4
1957	3229	+45	—250	+1.4
1958	3169	—47	—297	—1.5
1959	2202	+172	—125	+7.8
1960	1612	+26	—99	+1.6
1961	999	+23	—76	+2.3
1962	*Data not*	*available*		
1963	549	—3	—79	—0.6
1964	179	—17	—96	—9.5
1965	285	—5	—101	—1.8
Total	19675	—101		—0.5

no conclusion as to the reality of positive asymmetry in Maunder's sense: two stations report a prevalence of the number of groups on the eastern half of the solar disc and the other two stations report this prevalence on the western half. The Uccle and Zurich materials with negative asymmetry deny, at the same time, the applicability of the hypotheses explaining positive asymmetry by a factor on the Sun itself, that is the negative influence of the Earth and the inclination of the spot axis. This statement would only be unjustified if we allowed for yet another factor responsible for negative asymmetry, which would be so prominent in the case of Zurich and Uccle that

Table VII

Asymmetry of groups—Zurich

Year	E + W	E — W	Σ(W — E)	$\frac{E - W}{E + W}$ %
1926	1549	—129	—129	—8.33
1927	2017	+69	—60	+3.42
1928	2033	+143	+83	+7.03
1929	1702	+34	+117	+2.00
1930	1332	+186	+303	+13.96
1931	653	+11	+314	+1.68
1932	419	+37	+351	+8.83
1933	168	—16	+335	—9.52
1934	328	—22	+313	—6.71
1935	1083	+37	+350	+3.42
1936	2273	—75	+275	—3.30
1937	3484	+24	+299	+0.69
1938	3038	—30	+269	—0.99
1939	2858	—90	+179	—3.15
1940	2060	—70	+109	—3.40
1941	1497	—13	+96	—0.87
1942	1024	—18	+78	—1.76
1943	490	—6	+72	—1.22
1944	371	—19	+53	—5.12
1945	1083	+37	+90	+3.42
1946	2735	+41	+131	+1.50
1947	5090	—322	—191	—6.33
1948	4229	—131	—322	—3.10
1949	4522	—338	—660	—7.47
1950	2953	—275	—935	—9.31
1951	2198	—94	—1029	—4.28
1952	1264	—50	—1079	—3.96
1953	532	+8	—1071	+1.50
1954	192	—20	—1091	—10.42
1955	1477	+19	—1072	+1.29
1956	4240	+48	—1024	+1.13
1957	6009	—219	—1243	—3.64
1958	6232	—162	—1405	—2.60
1959	5401	+49	—1356	+0.91
1960	4278	—64	—1420	—1.50
1961	1866	—68	—1488	—3.64
1962	1204	+12	—1476	+1.00
1963	988	—48	—1524	—4.86
1964	378	—14	—1538	—3.70
1965	544	—4	—1542	—0.74
Total	85794	—1542		—1.80

Table VIII

Total and relative asymmetry of groups for the years 1950 to 1964

Station	E — W	$\frac{E - W}{E + W}$ %
Skalnaté Pleso	+432	+2.3
Tokyo	+234	+1.1
Uccle	—96	—0.5
Zurich	—878	—2.2

it would not veil positive asymmetry. So far, however, we have no hypothesis to explain negative asymmetry. It should be emphasized that the Zurich material is a supplemented series.

The negative asymmetry for Zurich and Uccle does not mean that the alternative under a) would apply, but the result obtained justifies us to concentrate our search for the cause of asymmetry onto the Earth.

The asymmetry variations in the Wolf number recorded at Skalnaté Pleso suggested a similar dependence on the phase of the 11-year cycle of solar activity also for the asymmetry of groups (see Tab. IX). The degree to which this phenomenon, so pronounced for Skalnaté Pleso, is attributable to local conditions may be determined by comparison with other stations. To this purpose we determined the asymmetry in the distribution of groups over the solar disc during the

Table IX

Number of years with positive and negative asymmetry of groups in different phases of the 11-year solar cycle (Skalnaté Pleso)

Period	Number of years n	+	—
1945—1948	4	3	1
1949—1954	6	1	5
1955—1958	4	4	0
1959—1964	6	3	3
ascending branch altogether	8	7	1
descending branch altogether	12	4	8

Table X

East—west asymmetry of groups in different phases of the solar cycle

Station	n	E	W	E — W	$\frac{E - W}{E + W}$ %
Period of increasing and high activity, 1945 to 1948					
Zurich	4	6381	6756	—375	—2.8%
Greenwich	4	6413	6186	+277	+1.8
Skalnaté Pleso	4	4314	4157	+157	+1.9
Period of decreasing and low activity, 1949 to 1954					
Zurich	6	5447	6216	—769	—6.6
Greenwich	6	5059	5133	—74	—0.7
Skalnaté Pleso	6	3206	3353	—147	—2.2
Tokyo	5	2127	2134	—7	—0.2
Uccle	5	2259	2570	—311	—6.4
Period of increasing and high activity, 1955 to 1959					
Zurich	5	11547	11812	—265	—1.1
Greenwich	4	7558	7142	+416	+2.8
Skalnaté Pleso	5	5168	4611	+557	+5.7
Tokyo	5	6192	6034	+158	+1.3
Uccle	5	5704	5518	+186	+1.7
Period of decreasing and low activity, 1960 to 1964					
Zurich	5	4266	4479	—213	—2.4
Skalnaté Pleso	5	2349	2398	—49	—1.3
Tokyo	5	2462	2379	+83	+1.7
Uccle	4	1684	1655	+29	+0.9
Bucuresti	4	2131	2162	—31	—0.7

period of ascending branches of the solar cycle and its maximum, and during that of the descending branches and the minimum. The results from the visual observations of the four stations examined are listed in Tabs. X and XI, together with the same values from Greenwich, whose material was obtained photographically.

Table XI

East—west asymmetry of groups during the periods of increasing and decreasing solar activity

Years	n	E + W	E — W	$\frac{E-W}{E+W}$ %	$\frac{E-W}{n}$
Greenwich Periods of increasing and high activity					
1916—1918	3	8680	+76	+0.9	+25
1925—1928	4	8896	+164	+1.8	+41
1935—1938	4	11516	+100	+0.9	+25
1945—1948	4	12599	+227	+1.8	+57
1955—1958	4	14700	+416	+2.8	+104
Total	19	56391	+983	+1.7	+52
Periods of decreasing and low activity					
1919—1924	6	5969	+67	+1.1	+11
1929—1934	6	5709	+109	+1.9	+18
1939—1944	6	8850	—130	—1.5	—22
1949—1954	6	10192	—74	—0.7	—12
Total	24	30720	—28	—0.9	—1
Zurich Periods of increasing and high activity					
1926—1930	5	8633	+303	+3.5	+61
1935—1937	3	6840	—14	—0.2	—5
1945—1948	4	13137	—375	—2.8	—94
1955—1959	5	23359	—265	—1.1	—53
Total	17	51969	—351	—0.7	—21
Periods of decreasing and low activity					
1931—1934	4	1568	+10	+0.6	+3
1938—1944	7	11338	—246	—2.2	—35
1949—1954	6	11663	—769	—6.6	—128
1960—1964	5	8745	—213	—2.4	—43
Total	22	33314	—1218	—3.7	—55

Comparing these stations we may conclude as follows:

1. Asymmetry is positive or less negative during the ascending and maximum activity than during the decreasing and minimum activity of the solar cycle. Asymmetry is negative or less positive during decreasing and low, than during ascending and maximum solar activity. This may be considered to prove the dependence of asymmetry on the phase of the cycle, as it appears at all stations regardless of the final asymmetry value.

2. This conclusion urgently requires an explanation of negative asymmetry or at least that of attenuated positive asymmetry during decreasing and low solar activity.

3. The negative asymmetry according to the Zurich series of visual observations and the negative asymmetry for the latest 11-year cycles according to the material of Greenwich (Kulešova 1963, Buzek 1954), that of Taškent (Kulešova 1963, Kulešova, Slonim 1957), Ebro (processed by the writer) and Mount Wilson (Bell, Glazer 1959) do not permit the conclusion that positive asymmetry may be considered real on the Sun or produced by solar phenomena (see Tab. XII). This prompted us dismiss the two most discussed theories of the origin of positive east—west asymmetry, and to examine the material of Skalnaté Pleso, as an independent station, by two methods for the effect of cloudiness on east-west asymmetry.

Table XII

Asymmetry of sunspots since 1930

Author	Station	Year	Phenomenon	$\frac{E-W}{E+W}$ %
Kulešova	Greenwich	1933—1954	area	—1.6
Romaňa, Menendez	Greenwich, Washington	1934—1943	area	—0.7
Kulešova	Ebro, Taškent	1937—1962	area	—1.0
Pajdušáková	Ebro	1955—1962	area	—3.8
Kulešova	Taškent	1935—1961	groups	—2.7
Pajdušáková	Greenwich	1936—1954	groups	+0.1
Pajdušáková	Zurich	1933—1964	groups	—2.5
Bell, Glazer	Mount Wilson	1937—1953	groups	—1.3
Pajdušáková	Skal. Pleso	1945—1965	groups	+1.8
Pajdušáková	Tokyo	1950—1964	groups	+1.1
Pajdušáková	Uccle	1950—1965	groups	—0.5
Kulešova, Slonim	Taškent	1944—1954	spots	—4.5

The meteorological factor

The possibility to explain east-west asymmetry, at least partly, by meteorological factors was hinted at by F. Link (1948, 1952, 1956). According to him, the importance of these factors is only secondary, ranking behind that of the planets, but he emphasizes that the observational conditions of the western half of the solar disc are less favourable than those of the eastern half. He shows, for instance, that the number of discontinued observations of chromospheric flares is higher on the part westward of the central meridian than on that eastward. The observations of the western part were interrupted by cloudiness, that is due to worsened observational conditions. Link also shows that solar activity in two different regions may have opposite meteorological effects and hence also cause unequal asymmetry. And this makes it imperative to study the meteorological effect on asymmetry in the material of a single station. The meteorological factor may act in two ways:

1. Active centres on the Sun may cause weather to change for the worse, but not until the active centre in question has migrated to the western half of the solar disc. In such cases, this active region, together with all its effects on the Sun, will be observed less frequently westward than eastward of the central meridian.

2. Longer observations of a certain phenomenon of solar activity, such as in the case of plotting spots in projection near the maximum, or corona—intensity observations by five degrees, need not always be completed, as they may get interrupted by cloudiness. During the many years of photosphere observations at Skalnaté Pleso we were almost forced into accepting the meteorological factor in this sense, so often did cloudiness prevent us from completing our observations. If observations are systematically started from the eastern limb, which is the rule at Skalnaté Pleso, the western half of the solar disc has the disadvantage of the eastern half, and this results in positive asymmetry.

We examined this unfavourable effect of worsening observational conditions on longer observations in the east—west asymmetry of the corona, as observed at Pic du Midi. Of the nine investigated stations, only Pic du Midi gives a systematic positive east—west asymmetry (Pajdušáková 1966). However, the connection between worsening observational conditions, even pending observation, and the observation of positive asymmetry by this coronal station, has been proved by more than one method.

The effect of meteorological factors on east—west asymmetry will be examined by two methods in the material of Skalnaté Pleso: We shall examine 1. the dependence of east-west asymmetry on precipitation and 2. the dependence of this asymmetry on the number of daily observations missed for long-lived groups.

Precipitation and asymmetry

The amount of precipitation may be considered an indicator of cloudiness and thus also of adverse observational conditions. If the meteorological factor is real, the amount of precipitation must be higher for positive asymmetry, and vice versa, lower for negative asymmetry (in combination with the psychological factor).

Tab. XIII gives the total and relative asymmetry on the number of groups for each year,

Table XIII

East-west asymmetry of sunspot groups and the annual precipitation level at Skalnaté Pleso

Groups			Precipitation in mm	
Year	E — W	$\frac{E-W}{E+W}$ %	amount	difference
1945	+54	+5.9	2155	+785
1946	+39	+1.8	1192	—178
1947	—29	—1.0	1261	—109
1948	+93	+3.6	1756	+386
1949	—71	—2.8	1677	+307
1950	—69	—3.7	1261	—109
1951	+21	+1.6	1174	—196
1952	—20	—3.7	1236	—134
1953	—1	—0.3	1262	—108
1954	—7	—9.3	1288	—82
1955	+61	+10.7	1657	+287
1956	+112	+6.0	1355	—15
1957	+121	+5.5	1139	—231
1958	+72	+2.7	1535	+165
1959	+191	+7.5	1207	—163
1960	+19	+0.8	1516	+146
1961	—71	—6.3	911	—459
1962	+25	+5.1	1507	+137
1963	—19	—3.9	1070	—300
1964	—3	—0.8	1228	—142
1965	+3	+1.3	1379	+9

together with the amount of precipitation and its yearly departure from the average of the period in question (1370 mm). Tab. XIV lists the amount of precipitation at Skalnaté Pleso for the periods with positive and negative asymmetry, and the number of years in keeping and not in keeping with the presumed dependence mentioned. The

Table XIV

Precipitation at Skalnaté Pleso during the periods of positive and negative asymmetry

Period	Asymmetry	Number of years +	—	Annual means of precipitation	Difference
1945—1948	+	3	1	1591	+221
1949—1954	—	4	2	1316	—54
1955—1960	+	3	3	1401	+31
1961—1964	—	4	0	1137	—191

Sign + indicates a positive asymmetry for a year with a high level of rainfall, or a negative asymmetry for a year with a low level of rainfall; sign — indicates the opposite association between rainfall and asymmetry.

tables show a rise in precipitation for positive asymmetry, when it is above average, and vice versa, a drop in precipitation, below the average of Skalnaté Pleso, for periods of negative asymmetry. Out of the 21 years examined, 15 satisfy the presumption that asymmetry is positive for enhanced precipitation and negative for low precipitation. This high percentage (71) of asymmetry coinciding with a certain meteorological factor may be considered to prove the fact that the meteorological factor influences asymmetry.

Missed days and asymmetry

The second method of examining the effect of weather on east-west asymmetry, that is an investigation of the observational conditions separately for the solar halves to the east and to the west of the central meridian, is perhaps even more conclusive. The observational conditions were investigated for long-lived groups assumed to had risen and set, in other words, for groups observable from the eastern to the western limb of the solar disc. From the material of Skalnaté Pleso we used all groups of the type D through I (according to the Zurich classification) with favourable observational conditions for at least 13 days. These groups were divided according to type into two groups: the first comprising types D, E and F, the second types G, H and I. The first group represents the ascending branch in the development of spot groups, the second the descending branch. This classification was based on the assumption that geo-active regions comprise, in the main, groups of the type D through F, so that it is precisely these regions which cause worsened weather conditions and thus also poorer observational conditions. If this assumption applies, groups of the type D to F ought to be observed less frequently on the western than eastern half of the solar disc. These largest groups, however, are, as a rule, not isolated, but accompanied by other groups, and their asymmetry may be positive due to the fact that the number of groups observed east of the central meridian is larger than of those observed west.

We determined for all these groups the days on which they were observed east and west of the central meridian and those they were not observed due to adverse weather conditions. It need not be emphasized that a larger number of days missed in the west will give positive asymmetry for these groups. However, if the asymmetry in types D, E and F is the same as the asymmetry in all groups, we are justified to conclude that adverse observational conditions for the western half are responsible for positive east-west asymmetry.

Tab. XV. lists the following values: the number of days on which the groups were observed, the number of missed observations for both group-types and for each year. The last column gives the total asymmetry in all groups. This examination covered the 14 years coinciding with the period beyond the minimum of the 18th and 19th cycle.

Table XV

The asymmetry on missing days for the groups of duration longer than 12 days

Types	D + E + F			G + H + I			all groups
Year	E	W	E—W	E	W	E—W	E — W
1946	12	15	—3	32	31	+1	+39
1947	55	53	+2	45	58	—13	—29
1948	45	71	—26	72	66	+6	+93
1949	54	47	+7	53	48	+5	—71
1950	19	16	+3	32	24	+8	—69
1951	25	17	+8	22	30	—8	+21
1952	10	13	—3	15	16	—1	—50
1956	51	60	—9	53	63	—10	+112
1957	24	33	—9	37	34	+3	+121
1958	109	133	—24	82	87	—5	+72
1959	49	69	—20	65	90	—25	+191
1960	37	30	+7	46	44	+2	+19
1961	9	4	+5	14	11	+3	—71
1962	14	17	—3	12	19	—7	+25

The numerical results show that of the 14 years in question, 11 satisfy the assumed influence of meteorological conditions on total asymmetry. The number of D, E and F-type observations missed did not influence total asymmetry only in three cases. Types D, E and F have better observational conditions before than after the passage across the central meridian. Of the total number of observations, those missed in the west exceed by 6.9 % those missed in the east.

The asymmetry of the second group of types, that is of types G, H and I, is not so closely associated with the total asymmetry of groups: for the 14 years in questions, the asymmetry of the missed observations only corresponds in 8 cases to the total asymmetry of all groups. Taking into account te relatively small number of years investigated, the observed distribution of agreement and disagreement, that is 8 and 6, may be quite accidental. The number of days missed for these types in the 18th cycle is even equal, that is 271, on the eastern and western half.

The years which contributed most markedly to the east-west asymmetry observed at Skalnaté Pleso were from 1956 to 1959 when the ratio of the days missed for types D, E and F observable for 13 or more days on the visible solar hemisphere was 233 : 295. Their relative asymmetry is rather marked: —11.7 %. Taking into account the fact that, as said before, precisely these groups are located in regions relatively abundant in groups, we are justified to conclude that adverse observational conditions due to active regions on the Sun may affect east-west asymmetry.

Explanation of negative east-west asymmetry

It is uncontested that negative asymmetry was ascertained by numerous authors, but it is also true that we have no hypothesis of its origin so far. This led certain authors to maintain that asymmetry is a phenomenon quite accidental, so that it is redundant to frame any hypotheses of its origin.

It is evident, however, that the negative asymmetry in the material of Zurich and Skalnaté Pleso cannot be considered a matter of chance. We do not hesitate to believe that its origin calls for explanation. The following is a tentative explanation of the phenomenon.

The hypotheses accounting for the origin of positive asymmetry are inapplicable to negative asymmetry, unless the cause in question were in connection, in one way or the other, with the 11-year cycle of solar activity. It, however, is unconcievable that the inclination of the spot axis, for instance, would point westward during the maximum and eastward during the minimum of solar activity. On the other hand, it is quite possible that the effect of solar activity on observational conditions (cloudiness, calm atmosphere) is more marked during the maximum that minimum, when negative asymmetry may by quite accidental. However, the occurrence of negative asymmetry in the material of Zurich and Skalnaté Pleso exceeds the degree attributable to chance— and this cannot be left unaccounted for.

The many years we spent to observe visually and to draw the photosphere in projection led us to the conclusion that the prevalence in the number of groups of the western over the eastern half of the solar disc may be accounted for as follows:

It is well known that the disappearing groups (no matter whether setting or decaying) recorded by the observer on the western half of the solar disc outnumber those recorded on the eastern half and, vice versa, that the beginnings of groups recorded on the eastern half outnumber those on the western half. We do not know for certain where a new group will form or rise, except in the case of recurrent groups, and thus we simply look for new groups. With setting or decaying groups the situation is much more favourable. The observer knows where to look for a decaying or setting group. And, especially when observational conditions are bad for visual observation, he uses the short spells of clear sky or steady image to inspect more in detail the suspect regions. The observer often takes the pain to search until he discovers a small decaying or setting group. Such cases are much more frequent to the west than to the east of the central meridian. It is therefore not exaggerated to say that this advantage of the western half of the disc apparently distorts the symmetry about the central meridian of the visibility curve of spots: the disappearing spots found on the western half of the disc are smaller than the appearing spots found on the eastern half (Minnaert 1939, Kopecký 1956).

The factor underlying our explanation of the origin of east-west asymmetry is given by a certain characteristic of the observer, and hence we shall call it the psychological factor.

The psychological factor may also account for the type of III east-west asymmetry. Maunder may have found that rising groups outnumber setting groups, but materials processed more recently show that this is not the case: the groups observed in the western border-region outnumber those in the eastern border-region. Tab. XVI gives among others, the relative asymmetry in the area of spots or in the number of groups in border belts 20° to 26° wide.

Table XVI

The asymmetry of rising and setting sunspots

Autor	Station	Years	Phenomenon	Asymmetry
Waldmeier	Zurich	1936—1943	groups	—3.2
Gleissberg	Mount Wilson	1943—1945	groups	—2.2
Roggenhausen	German Stations	1943—1949	groups	—1.2
Bell, Glazer	Mount Wilson	1937—1953	groups	—2.9
Kulešova	Greenwich	1923—1954	areas	—4.1
Kulešova	Taškent	1935—1961	groups	—6.7
Kulešova	Taškent	1937—1962	areas	+2.7
Pajdušáková	Greenwich	1931—1954	groups	—1.3
Pajdušáková	Zurich	1926—1963	groups	—4.5
Pajdušáková	Uccle	1950—1963	groups	—2.1

The psychological factor must not be mistaken for inconscientiousness on the part of the observer. In this effort not to omit any spot or goup still observable, the observer concentrates his attention on regions he knows to have had a group the previous day. We believe that this is quite a natural quality of every good observer. This concentration upon the western hemisphere is more marked during low and decreasing solar activity than during increasing and maximum activity. The reasons why the western half of the disc is in a position especially disadvantageous during maximum activity, and for observations started at the eastern limb (which is the normal procedure at Skalnaté Pleso and, most likely, also at other stations) are as follows:

a) The possibility of the observation being interrupted by cloudiness or terminating in poorer observational conditions. The reverse, that is termination in better observational conditions, is impossible, since we repeat the observation if observational conditions improve.

b) The observer's fatigue, especially if the number of sunspots is as large as it was over the latest two maxima (the monthly average was more than 300 at Skalnaté Pleso).

c) The feeling of satisfaction over an extraordinarily large number of groups and spots may lead to less careful inspection of the western half of the disc.

The following is to show that it is easy quite unintetionally to infer negative asymmetry in the number of groups at the Zurich station, with its supplemented observational series, and hence systematic negative asymmetry.

From 1932, when the cumulative sum of total asymmetry in the number of groups for the foregoing 7 years reached the maximum of +351 positive value, until 1965 included, the number of groups observed on the western half of the disc exceeded by 1894 those observed on the eastern half. This period includes about 420 rotations, so that each rotation has, on the average, almost 5 observations of groups more on the western than on the eastern half of the disc. If we take into consideration the fact that this period had three maxima, the highest ones on record, and that certain rotations had as much as hundred groups, it is easy to get an excess of five observations, in favour of the western half at certain stations.

In a supplemented observational series, such as that of the Zurich station, the effect of the psychological factor, which leads to negative east-west asymmetry, may cumulate; on the other hand, however, the unfavourable effect of observational conditions and the errors of the observer, which result in omitted groups at one station, may be quite eliminated.

Conclusions

1. The effect of observational conditions influenced by meterological factors on east-west asymmetry has been proved by two methods, two tests. The meteorological factor is especially marked if solar activity is enhanced. The meteorological factor may get completely eliminated in a series of observations supplemented by observations of more stations.

2. The prevalence of the western half of the solar disc in the number of groups may be accounted for by the psychological factor. The effect of this factor associated with the observer is most likely greatest if solar activity deacreses or is low. This prevalence of the western half of the disc may become more pronounced in the supplemented observational series, because the errors of more stations may cumulate.

3. Combined, these two factors may account for both the negative east-west asymmetry, as seen in the supplemented Zurich series which is obtained by visual observations, and the variability of positive and negative asymmetry during the 11-year cycle for one station, such as Skalnaté Pleso.

4. A discussion of east-west asymmetry is only justified after elimination of the effects of these factors.

5. The psychological and meteorological factor may be eliminated by the photographic method provided:

a) any instrumental error is eliminated,

b) the photosphere is photographed every day with favourable atmospheric conditions,

c) two independent evaluations are made, one starting at the eastern, the other at the western limb of the solar disc.

6. The photographic method applied under the conditions mentioned does not eliminate the natural positive east-west asymmetry which results from the non-symmetrical development of groups in time: sometimes during the second and almost always during the third and further rotation, the area of the groups is larger when they rise than when they set (Burzek 1954).

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Ľ. PAJDUŠÁKOVÁ

VÝCHODO-ZÁPADNÁ ASYMETRIA SLNEČNÝCH ŠKVŔN

Problém východo-západnej asymetrie javov slnečnej aktivity zatiaľ nie je doriešený.

V predkladanej práci sa konštatuje východo-západná asymetria škvŕn na niektorých staniciach s vizuálnym pozorovaním a rozoberajú sa niektoré možné príčiny vyvolávajúce asymetriu.

Mesačné relatívne čísla zo Skalnatého Plesa počas 18. a 19. cyklu vykazujú systematicky kladnú asymetriu len v období vzostupnej a vysokej slnečnej činnosti. V období klesajúcej a nízkej činnosti je asymetria záporná. Podobnú závislosť asymetrie od fázy cyklu vykazujú i iné stanice: v období zostupnej a nízkej činnosti je asymetria záporná alebo menej kladná ako v období vzostupu a maxima; v období vzrastajúcej a vysokej činnosti je asymetria kladná alebo menej záporná ako v období nízkej a klesajúcej činnosti.

Za to isté obdobie (roky 1950 až 1965) vyšetrované stanice nedávajú rovnaký výsledok asymetrie: dve stanice, Skalnaté Pleso a Tokyo, majú asymetriu kladnú, a dve, Zürich a Uccle, asymetriu zápornú. Ak vezmeme do úvahy výsledky i z iných staníc a ďalších autorov (pozri tabuľku XII), nemožno hovoriť s istotou o kladnej asymetrii existujúcej na Slnku ako dôsledku nepriaznivého vplyvu Zeme alebo ako vyvolanej príčinou tkvejúcou na Slnku, napríklad sklonom osi škvŕn. Musí sa predpokladať, že sú možné i iné príčiny vyvolávajúce asymetriu.

Na pozorovaniach z jednej stanice sa dá študovať vplyv meteorologického faktora. Materiál zo Skalnatého Plesa ukázal nasledovný výsledok:

1. V rokoch so zvýšeným množstvom zrážok vyskytuje sa prevažne asymetria kladná, s množstvom pod priemer asymetria záporná.

2. Skupiny typov D, E a F, trvajúce na viditeľnej polovici Slnka najmenej 13 dní, vykazujú na západ od centrálneho meridiánu viac vynechaných dní pre nepriaznivé počasie ako na východ. Súhlas asymetrie všetkých skupín s touto asymetriou typov D, E a F je vysoký.

Týmito dvoma spôsobmi považujem vplyv meteorologického faktoru na východo-západnú asymetriu za dostatočne dokázaný.

Ak sa pozorovanie fotosféry systematicky začína od východného okraja, západná polovica je voči východnej v určitej nevýhode, hlavne za veľmi vysokej slnečnej činnosti z nasledujúcich dôvodov: a) počas pozorovania sa môžu zhoršiť pozorovacie atmosferické podmienky, b) únava pozorovateľa, c) uspokojenie pozorovateľa z vysokého počtu skupín a škvŕn môže viesť k zníženiu pozornosti na západnom okraji. Pri nízkej aktivite tieto javy nemusia vôbec vystupovať.

V doplňovanom rade pozorovaní, akým je materiál z Zürichu, meteorologický faktor a chyby pozorovateľa z únavy, resp. ,,uspokojenia" sa nemôžu prejavovať v takej miere ako na samostatnej stanici, pretože niekoľko staníc s niekoľkými pozorovateľmi navzájom tieto chyby v doplnenom rade vylučujú.

Zápornú asymetriu ani na Skalnatom Plese v určitých obdobiach, ani v Zürichu nemôžeme hodnotiť len ako náhodný výskyt z dvoch možných javov. I záporná asymetria musí byť teda nejakou príčinou vyvolávaná. Domnievam sa, že záporná asymetria môže byť vyvolávaná takzvaným psychologickým faktorom: západná polovica slnečného disku je voči východnej vo výhode v tom, že pozorovateľ vie, kde má hľadať zanikajúcu alebo zapadajúcu skupinu, zatiaľ čo na východnej polovici miesto vznikajúcich a vychodiacich skupín (vyjmúc rekurenté skupiny) nie je známe.

Následky tohto psychologického faktora, ktorý zvýhodňuje západnú polovicu disku, v doplňovanom rade sa môžu z jednotlivých staníc kumulovať. Psychologický faktor je i v období nízkej a klesajúcej činnosti účinnejší ako v období vysokej činnosti.

Meteorologický i psychologický faktor možno vylúčiť fotografickou metódou za nasledujúcich podmienok:

1. Rad fotografií fotosféry je doplňovaný z niekoľkých staníc.

2. Fotografie sú vyhotovované len za dobrých atmosferických podmienok.

3. Platne vyhodnocujú dvaja pracovníci, a to jeden od východného a druhý od západného okraja slnečného disku.

Л. ПАЙДУШАКОВА

ВОСТОЧНО-ЗАПАДНАЯ АССИММЕТРИЯ СОЛНЕЧНЫХ ПЯТЕН

Проблема восточно-западной ассимметрии явлений солнечной активности пока что не решена полностью.

В настоящей статье констатируется восточно-западная ассимметрия пятен у некоторых станций с визуальным наблюдением и высказываются некоторые возможные причины, вызывающие ассимметрию.

Месячные относительные числа из Скальнатого Плеса в течение 18 и 19 циклов обнаруживают систематически положительную ассимметрию только в период возрастающей и высокой солнечной активности. В период уменьшающейся и низкой активности ассимметрия отрицательна. Подобную зависимость ассимметрии от фазы цикла обнаруживают и другие станции: в период уменьшающейся и низкой активности ассимметрия отрицательна или менее положительная по сравнению с периодом возрастания и максимума; а в период возрастающей и высокой активности ассимметрия положительна или менее отрицательна, чем в период низкой и уменьшающейся активности.

За тот же самый период (1950—1956 годы) исследуемые станции не дают одинаковых результатов ассимметрии: две станции, Скальнате Плесо и Токио, имеют положительную ассимметрию и две, Цюрих и Уккле — отрицательную ассимметрию. Если взять во внимание данные других станций и иных авторов (см. таблицу 12), тогда нельзя с уверенностью говорить о положительной ассимметрии, существующей на Солнце, как результате нежелательного влияния Земли, или как вызванной по причине, покоющейся на Солнце, например наклоном оси пятен. Надо предполагать, что должны быть и другие причины, вызывающие ассимметрию.

По наблюдениям одной из станций можно изучать влияние метеорологического фактора. Из материалов Скальнатого Плеса можно сделать следующие выводы:

1. В годы с увеличенным количеством осадков преимущественно встречается положительная ассимметрия, и в годы с осадками ниже средней величины - ассимметрия отрицательная.

2. Группы типов D, E и F, длящейся на видимой половине Солнца наименее 13 дней, обнаруживают на запад от центрального меридиана больше пропущенных дней из-за плохих метеорологических условий, чем на востоке. Соответствие ассимметрии всех пятен с ассимметрией типов D, E и F достаточно точное.

Считаю, что этими двумя способами влияние метеорологического фактора на восточно-западную ассимметрию вполне доказано.

Если наблюдение фотосферы систематически начинается от восточного края, тогда западная половина относительно восточной находится в определенной невыгоде, особенно при очень высокой солнечной активности по следующим причинам: а) в течение наблюдений могут ухудшиться атмосферные условия видимости; б) усталость наблюдателя; в) удовлетворение наблюдателя большим количеством групп и пятен может привести к снижению внимательности на западном крае. При низкой активности приведенные явления могут вообще не появляться.

В ряде дополнительных наблюдений, например материалы из Цюриха, метеорологический фактор и ошибки наблюдателя из-за усталости, или же ,,успокоенности" не могут проявляться в такой мере, как на самостоятельной станции, поскольку несколько станций с несколькими наблюдателями взаимно исключают эти ошибки с учётом дополнительных данных.

Отрицательную ассимметрию ни у Скальнатого Плеса в определенные периоды, ни у Цюриха нельзя оценивать только как случайное появление из двух возможных явлений, то есть отрицательная ассимметрия должна быть некоторой причиной вызвана. Предполагаю, что отрицательная ассимметрия может быть вызвана так называемым психологическим фактором: западная половина солнечного диска относительно восточной находится в той выгоде, что наблюдатель знает, где должен искать угасающую или заходящую группу, в то время как на восточной половине положение возникающих и восходящих групп (за исключением рекурентных групп) неизвестно.

Результаты психологического фактора, который ставит в более выгодное положение западную половину диска, в дополнительном ряде наблюдений из отдельных станций могут накопляться. Психологический фактор в период низкой и уменьшающейся активности становится более ощутимым, чем в период высокой активности.

Метеорологический и психологический факторы можно исключать фотографическим методом при следующих условиях:

1. количество фотографий фотосферы дополняется из нескольких станций;

2. фотографии делаются только при хороших атмосферных условиях;

3. снимки пересмотриваются независимо двумя работниками: одним от восточного, а другим от западного края солнечного диска.