ΣΥΝΕΔΡΙΑ ΤΗΣ 4ΗΣ ΙΟΥΝΙΟΥ 1964

ΠΡΟΕΔΡΙΑ ΙΩΑΝΝ. ΞΑΝΘΑΚΗ

ΠΡΑΞΕΙΣ ΚΑΙ ΑΠΟΦΑΣΕΙΣ ΤΗΣ ΑΚΑΔΗΜΙΑΣ

ΕΚΛΟΓΗ ΞΕΝΩΝ ΕΤΑΙΡΩΝ ΚΑΙ ΑΝΤΕΠΙΣΤΕΛΛΟΝΤΩΝ ΜΕΛΩΝ

Ὁ **Πρόεδρος** ἀνακοινοῖ τὴν δημοσίευσιν εἰς τὴν Ἐφημερίδα τῆς Κυβερνήσεως τοῦ Βασ. Δ/τος ἐκλογῆς α) ξένων ἑταίρων τῶν κ. κ. **H. Stille, Oth. Kühn, P. Montel.** β) ἀντεπιστελλόντων μελῶν τῶν κ. κ. **Octave Merlier, Br. Lavagnini, Arm. Delatte, P. von der Mühl, B. Schweitzer.**

ΑΝΑΚΟΙΝΩΣΕΙΣ ΜΕΛΩΝ

ΑΣΤΡΟΝΟΜΙΑ.– **A Study of the Sunspot magnetic field Strengths,** *by **John Xanthakis****. (Research and Computing Center, Academy of Athens).

It is well known, that the total sunspot magnetic field strengths vary during each sunspot cycle in the same general way, as the other characteristics of solar activity (relative sunspot numbers, areas of the sunspots, faculae etc.). It is accepted today, that the variation of the total sunspot magnetic field strengths follows in general the variation of the areas of the whole spots or the umbrae. On the other hand, it has been shown already, that the main part of the variation of the annual values of most of the characteristics of solar activity can be satisfactorilly expressed as function of the corresponding time of rise expressed in solar rotations, in months or in years (Xanthakis

* ΙΩ. ΞΑΝΘΑΚΗ, Ἀναλυτικὴ ἔκφρασις τῆς μεγίστης ἐντάσεως τοῦ μαγνητικοῦ πεδίου τῶν ἡλιακῶν κηλίδων.

1962). These results led us to investigate, whether similar relations between the total sunspot magnetic field strengths and the time of rise of the corresponding sunspot cycle could be found.

The simplest approach would be to examine to this purpose the daily values of the quantity Σh, where h is the strength of the magnetic field of each sunspot visible on the solar disc during the corresponding day. In this way, the same sunspots contributing to the determination of the relative sunspot number R as well as of the total sunspot area A, would also contribute to the determination of the corresponding value of the quantity Σh.

This approach, however, cannot be followed at present, as no long series of observations of the values of h is yet available. On the other hand, exists already the long series of the values of H i.e. the maximum values of the magnetic field strengths observed for each group of sunspots during each passage of it over the visible solar disc, published by the Mount Wilson Observatory. Contrary to Σh, the values of ΣH do not correspond precisely to the corresponding values of R or A, as in the determination of the values of R and A contribute every isolated sunspot or group of sunspots during all days of its visibility on the solar disc, while for the determination of ΣH each group of sunspots contributes only once during the time interval of each passage of it over the visible solar hemisphere. Nevertheless, and because of the fact, that the quantity ΣH could also be finally proven to have an important physical significance, it seemed worthwhile to examine whether ΣH too, which in the following will be designated as «the sum of the maximum magnetic field strengths of the sunspot groups observed during a certain interval of time», could be correlated to the corresponding value of the time of rise.

To this purpose, let us call ΣH_N, ΣH_S, and ΣH the sums of the values of H corresponding to the sunspot groups observed each year on the northern and the southern solar hemisphere as well as on the entire solar disc respectively, expressed in units of 100 gauss, i.e. $\Sigma H = \Sigma H_N + \Sigma H_S$. The numerical values of ΣH_N, ΣH_S and ΣH, wich have been kindly communicated to the author by Miss Barbara Bell of the Harvard College Observatory, are given in the second, third and fourth column of Table I. The values given in parentheses correspond to the sunspots belonging to a new sunspot cycle. The fifth column of Table I gives the current number N of the successive sunspot cycles and the sixth, seventh and eighth columns give respectively the times of rise T_N, T_S, and T corresponding to the northern and southern solar hemisphere and the entir solar disc. The maxima of the values of ΣH_N, ΣH_S and ΣH do not always coincide with the maxima of the corresponding values of the sunspot areas. In cycle No 19, for example, the maximum of ΣH took place during the year 1958, while the maximum of the corresponding value for the sunspot areas occured one year earlier (1957). For this reason the times of rise T_N, T_S and T corresponding to the values of ΣH_N, ΣH_S and ΣH do not always coincide with the values of the corresponding quantities for the sunspot areas. As we are interested in making comparisons between the values of ΣH_N, ΣH_S and ΣH and the corresponding values of the sunspot areas, however, we will use in the case of the quantities ΣH_N, ΣH_S and ΣH too the values T_N, T_S and T of the time of rise referred to the sunspot areas, which are given in the sixth, seventh and eighth column of Table I.

The data given in Table I show, that the values $(\Sigma H_m)_N$, $(\Sigma H_m)_S$ and (ΣH_m) of ΣH_N, ΣH_S and ΣH corresponding to the years 1917, 1928, 1937, 1947 and 1957 during which the maxima of the sunspot areas occured, can be satisfactorilly expressed as functions of the corresponding times of rise T_N, T_S or T expressed in years with the help of the relations:

$$(1) \quad (\Sigma H_m)_N = a\{b(b-1) + b(T_O - T_N)\} - b T_O (T_O - T_N)^2 \sin N\frac{2\pi}{8}$$

$$(2) \quad (\Sigma H_m)_S = a\{b(b-1) + b(T_O - T_S)\}$$

$$(3) \quad (\Sigma H_m) = a\{a + b(T_O - T)\} - 10\, a \sin N\frac{2\pi}{4}$$

where N =1,2,3... 18,19 the current number of the successive sunspot cycles and

$$a = 70,\ b = 6 \text{ and } T_O = 7.$$

$$\text{or} \quad T_O = 7,\ b = (T_O - 1),\ a = 10\, T_O$$

Relations (1), (2) and (3), which are given with due caution, because they are based on a limited number of cycles (cycles No 15-19), show, that the values of the annual sums ΣH corresponding to the years of the maximum sunspot areas vary from cycle to cycle of solar activity in a different way for the northern and the southern solar hemisphere and the entire solar disc. From relation (2) we see, in fact, that for the southern solar hemisphere the relation between the values of $(\Sigma H_m)_S$ and the corresponding time of rise T_S is linear. For the northern solar hemisphere on the contrary a periodic term with a period equal to 8 solar cycles is added, the amplitude of which depends on the time of rise T_N. Finally, for the entire solar disc we have

TABLE I

Annual sums of the maximum magnetic field strengths of the sunspot groups observed on the northern and the southern solar hemisphere and the entire solar disc during the years 1917 - 1958 (in units of 100 gauss). Mount Wilson observations.

(1) Year	(2) Northern $(\Sigma H)_N$		(3) Southern $(\Sigma H)_S$			(4) Total (ΣH)		(5) N	(6) Time of rise in years T_N	(7) T_S	(8) T
1917	3650		3116			6766		15	3.9	4.1	4.2
18	3034		2875			5909		(1913-1923)			
19	2025		2630			4655					
20	1317		1298			2615					
21	1000		833			1833					
22	577	(5)	344			921	(5)				
23	156	(69)	109	(103)		265	(172)				
24	115	(819)	235			350	(819)				
25	1950		1325			3275					
26	2024		2070			4094					
27	1695		2666			4361					
28	2401		2507			4908					
29	2382		2320			4702		16	6.3	5.3	6.8
30	1536		1166			2702		(1924-1933)			
31	939		498			1437					
32	531		370			901					
33	365	(9)	23	(4)		388	(13)				
34	151	(210)	18	(384)		169	(594)				
35	38	(1080)	1498		(38)	2576					
36	1728		2239			3967					
37	3190		2485			5675		17	3.4	6.0	3.6
38	2371		2639			5010		(1934-1944)			
39	2168		2491			4659					
40	1590		2109			3699					
41	1320		998			2318					
42	995		863			1858					
43	726		216	(48)		942	(48)				
44	52	(206)	76	(318)	(128)	524					
45	620		45	(1294)	(45)	1914					
46	2191		2160			4351					
47	2997		3487			6484		18	3.2	3.3	3.2
48	3048		3149			6197		(1945-1954)			
49	3608		2816			6424					
50	2563		1754			4317					
51	1632		1303			2935					
52	801		889			1690					
53	524		280			804					
54	38	(139)	48	(133)	(86)	272					
55	1324		4	(772)	(4)	2096					
56	3373		2	(2998)	(2)	6371					
57	3343		3857			7200		19	3.3	3.3	3.3
58	4068		3666			7714		(1955-			

again a periodic term with a period equal to 4 sunspot cycles, the amplitude of which is now constant and equal to 10a = 700 units. From relations (1), (2) and (3) we also see, that the maxima of the quantities ΣH_N, ΣH_S and ΣH vary from cycle to cycle of solar activity in a different way, than the maxima of the sunspot areas, which are related to the time of rise with second degree relations (Xanthakis, 1962).

Table II gives the observed values of $(\Sigma H_m)_N$, $(\Sigma H_m)_S$ and (ΣH_m) as well as the values of these quantities computed with the help of relations (1), (2) and (3).

TABLE II

Cycle	Year	$(\Sigma H_m)_N$			$(\Sigma H_m)_S$			(ΣH_m)		
No	of maximum	Obs.	Comp.	O-C	Obs.	Comp.	O-C	Obs.	Comp.	O-C
15	1917	3650	3688	— 38	3116	3318	—202	6766	6776	—10
16	1928	2401	2396	+ 5	2666	2814	—148	4908	4984	—76
17	1937	3190	3227	— 37	2639	2520	+119	5675	5628	+47
18	1947	2997	3110	—113	3487	3654	—167	6484	6496	—12
19	1957	3343	3206	+137	3857	3654	+203	7200	7154	+46

The annual values of the sums of the maximum magnetic field strengths.

The main part of the variation of the annual values of the sums of the maximum magnetic field strengths within each sunspot cycle can be satisfactorilly expressed, as in the case of the sunspot areas, as a function of the corresponding time of rise with the help of the following relations:

(4) $\Sigma H_N \cong (\Sigma H_m)_N \cos^2 k \frac{\pi}{2\Omega_{1,2}}$

(5) $\Sigma H_S \cong (\Sigma H_m)_S \cos^2 k \frac{\pi}{2\Omega_{1,2}}$

(6) $\Sigma H \cong (\Sigma H_m) \cos^2 k \frac{\pi}{2\Omega_{1,2}}$

where k = 0 for the year of maximum solar activity and k = 1, 2, 3,... for the first, second, third,... year before or after the year of maximum. The parameter $\Omega_{1,2}$ is related to the time of rise T with the relation $\Omega_1 = T$ for the years preceding the sunspot maximum and $\Omega_2 = 11 - T$ for the years following the maximum.

A study of the differences between the observed values of $\Sigma H_N, \Sigma H_S$ and ΣH and the values of these quantities computed with the help of the relations (4), (5) and (6) shows, on the other hand, that these differences present, as in the case of other characteristics of solar activity studied so far (relative sunspot numbers, numbers of sunspot groups and areas of the sunspots and the faculae), a periodic variation with semi-periods equal to 2, 3, 6 and 8 years. Moreover the amplitudes of these periodic terms, which will be represented by $G^N_{1,2}$, $G^S_{1,2}$ and $G_{1,2}$ for the northern and the southern solar hemisphere and the entire solar disc respectively, change from cycle to cycle of solar activity also in a periodic way. If we represent by G_1, G_2 the values of $G_{1,2}$ corresponding to the ascending and the descending branch of solar activity respectively, then the values of these quantities for the cycles with even or odd current number are given respectively by the following relations:

a) Cycles with even current number N

$$G^N_1 = -4 f a_1 \sin k \frac{\pi}{2} - 2 f b_1 \sin k \frac{\pi}{4} \qquad G^N_2 = 4 f b_1 \sin k \frac{\pi}{6}$$

$$(7) \quad G^S_1 = -4 f b_1 \sin k \frac{\pi}{2} \qquad G^S_2 = -10 f a_2 \sin k \frac{\pi}{8}$$

$$G_1 = -4 f b_3 \sin k \frac{\pi}{2} \qquad G_2 = 2 f a_1 \sin k \frac{\pi}{2} + 4 f b_1 \sin (k-1) \frac{\pi}{2}$$

b) Cycles with odd current number N

$$G^N_1 = 6 f B \sin k \frac{\pi}{3} \qquad G^N_2 = -6 f a_1 \sin k \frac{\pi}{4}$$

$$(8) \quad G^S_1 = 2 f a_2 \sin k \frac{\pi}{4} \qquad G^S_2 = 4 f b_0 \sin k \frac{\pi}{6}$$

$$G_1 = 4 f b_0 \cos k \pi \qquad G_2 = 8 f b_2 \sin k \frac{\pi}{8}$$

where,

$$f = ab = 420$$

$$a_1 = \cos N \frac{2\pi}{8} \qquad b_0 = \sin N \frac{2\pi}{4} \qquad b_2 = \sin (N-1) \frac{2\pi}{8}$$

$$(9) \quad a_2 = \cos (N-{}^1/_2) \frac{2\pi}{8} \qquad b_1 = \sin N \frac{2\pi}{8} \qquad b_3 = \sin (N+{}^1/_2) \frac{2\pi}{8}$$

$$B = \sin^2 (N-1) \frac{2\pi}{8} - \sin (N+1) \frac{2\pi}{8}$$

Therefore, the annual values of the sums of the maximum magnetic field strengths of the sunspot groups observed during the years 1917-1958, for which observational data are available, can be satisfactorilly expressed as functions of the corresponding time of rise (T_N, T_S or T) with the help of the relations:

$$\Sigma H_N = \left\{ (\Sigma H_m)_N + G^N_{1,2} \right\} \cos^2 k \frac{\pi}{2\Omega^N_{1,2}}$$

(10) $$\Sigma H_S = \left\{ (\Sigma H_m)_S + G^S_{1,2} \right\} \cos^2 k \frac{\pi}{2\Omega^S_{1,2}}$$

$$\Sigma H = \left\{ (\Sigma H_m) + G_{1,2} \right\} \cos^2 \frac{\pi}{2\Omega_{1,2}}$$

In Fig. 1 the continuous lines represent the observed values of the annual sums of the maximum magnetic field strengths of the sunspot groups observed during the years 1917-1958 (a) on the northern (above) and the southern (below) solar hemisphere and (b) on the entire solar disc, and the dashed lines the values of these quantities computed with the help of the relations (10). As the values of the time of rise T_N, T_S and T corresponding to the sunspot areas are known also for the cycles No 12-14, for which no observational data concerning the maximum magnetic field strengths are available, we have computed for these cycles too, as well as for the remaining part of the current cycle (1958-1964) the annual values of the sums of the maximum magnetic field strengths corrensponding to the northern and the southern solar hemisphere and the entire solar disc with the help of the relations (10) and the values found are given in Fig. 1 by dashed lines. The precision of the analytical expression given by relations (10) computed with the help of the formula $\left(1 - \frac{\sigma}{\Sigma H}\right) 100\%$ is respectively equal to

88% for the northern solar hemisphere
87% » » southern » »
92% » » entire solar disc.

In spite of these high values of the precision, one should consider relations (1)-(3) and (10) and especially their exprapolation in the past and future (descending branch of the cycle No 19) with due caution, because of the limited number of sunspot cycles used for their deduction. The limited observational data concering the maximum magnetic field strengths of the sunspot groups available today, do not allow us also to verify the cyclic

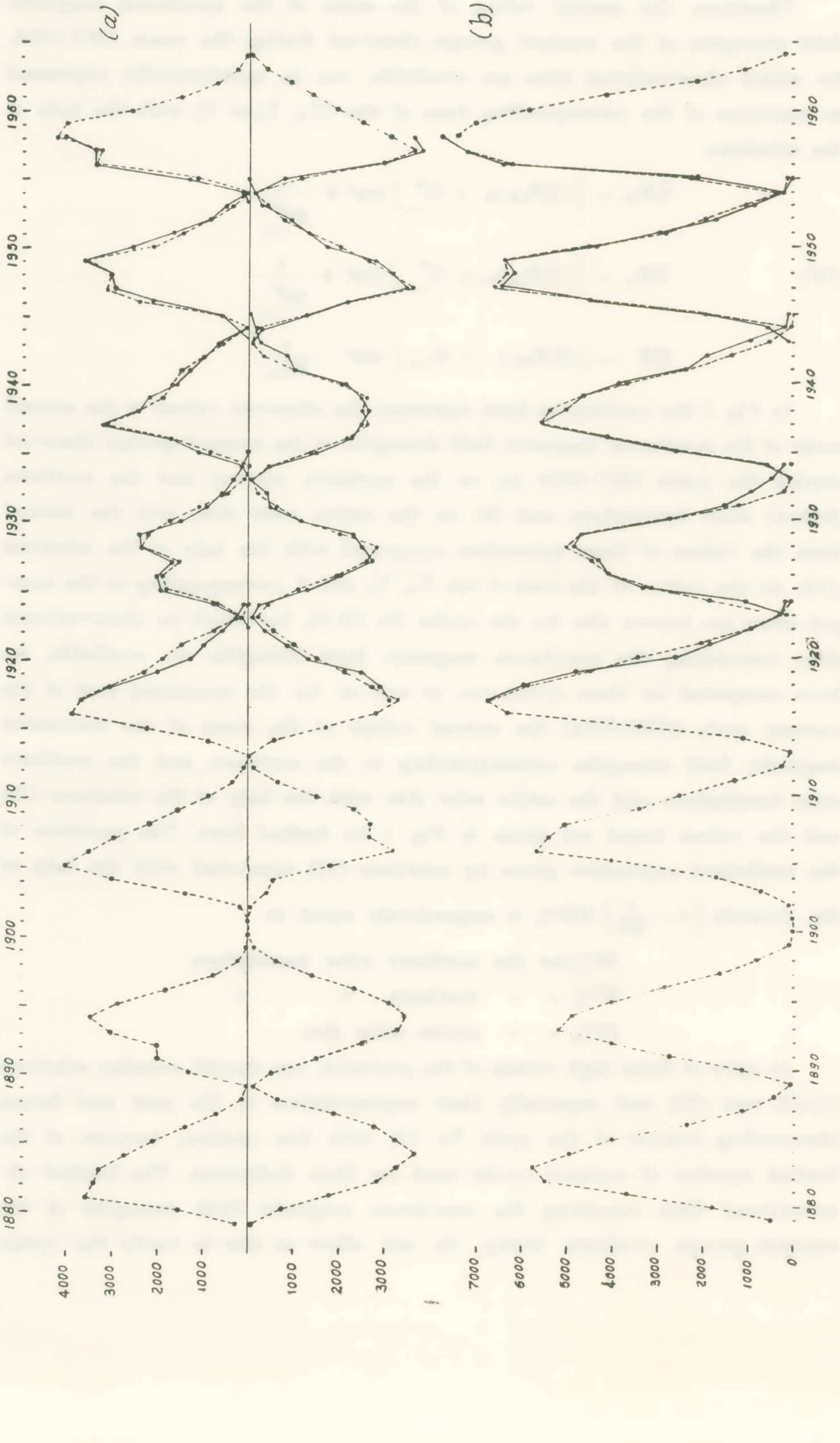
(a)
(b)
1880
1890
1900
1910
1920
1930
1940
1950
1960
4000
3000
2000
1000
1000
2000
3000
7000
6000
5000
4000
3000
2000
1000
0

Fig. 1.

variation of the coefficients of the relations (7) and (8). There are, however, as we shall see in the following sections, some indirect indications about that.

The asymmetry of the values of the sums of the maximum magnetic field strengths between the two solar hemispheres.

Both relations (1) and (2), which give the values of the annual sums of the maximum magnetic field strengths of the sunspot groups observed during the years of maximum of the sunspot areas, as well as relations (4) and (5) which give the values of these quantities for the successive years of each sunspot cycle show, that the values of these sums vary in a different way on the two solar hemispheres. We thus have an asymmetry in the distribution of the sums of the maximum magnetic field strengths over the two solar hemispheres, which can be expressed with the help of the quantity:

$$Q_H = \frac{\Sigma H_N - \Sigma H_S}{\Sigma H_N + \Sigma H_S}$$

We are going to show, that this asymmetry Q_H can also be expressed as a function of the time of rise and the periodic terms $G^N_{1,2}$, $G^S_{1,2}$. In fact, as the differences $T - T_N$, $T - T_S$ are generally small, we can put in a first approximation

$$\cos^2 k \frac{\pi}{2\Omega^N_{1,2}} \simeq \cos^2 k \frac{\pi}{2\Omega^S_{1,2}} \simeq \cos^2 k \frac{\pi}{2\Omega_{1,2}}$$

Then relations (10) give:

$$(11) \qquad Q_H = \frac{(\Sigma Hm)_N - (\Sigma Hm)_S}{(\Sigma Hm)_N + (\Sigma Hm)_S} + \frac{G^N_{1,2} - G^S_{1,2}}{(\Sigma Hm)_N + (\Sigma Hm)_S}$$

From relations (1) and (2) we have:

$$(\Sigma Hm)_N - (\Sigma Hm)_S = 2f\,(T_S - T_N) - 10^{-1} . 2f\,(T_O - T_N)^2\, b_1$$

$$(\Sigma Hm)_N + (\Sigma Hm)_S = 10 . 2f + 2f\,(T_S + T_N) - 10^{-2} . 2f\,(T_O - T_N)^2\, b_1$$

Also relations (7) and (8) give:

a) for the cycles with even current number N

$$G^N_1 - G^S_1 = -2f \left\{ 2\,(a_1 - b_1) \sin k \frac{\pi}{2} + b_1 \sin k \frac{\pi}{4} \right\}$$

$$G^N_2 - G^S_2 = 2f \left\{ 2b_1 \sin k \frac{\pi}{6} + 5\,a_2 \sin k \frac{\pi}{8} \right\}$$

b) for the cycles with odd current number N

$$G_1^N - G_1^S = 2f \left\{ 3\,B \sin k \frac{\pi}{3} - a_2 \sin k \frac{\pi}{4} \right\}$$

$$G_2^N - G_2^S = -2f \left\{ 3a_1 \sin k \frac{\pi}{4} + 2b_0 \sin k \frac{\pi}{6} \right\}$$

Relation (11) can thus be written:

a) for the cycles with even current number N

(12)
$$Q_H = \frac{A}{C} - \frac{10}{C} g_1 \quad \text{before the maximum}$$
$$Q_H = \frac{A}{C} + \frac{10}{C} g_2 \quad \text{after the maximum}$$

b) for the cycles with odd current number N

(13)
$$Q_H = \frac{A}{C} + \frac{10}{C} g_1' \quad \text{before the maximum}$$
$$Q_H = \frac{A}{C} - \frac{10}{C} g_2' \quad \text{after » »}$$

where

$$A = 10\,(T_S - T_N) - (T_O - T_N)^2 \cdot b_1$$
$$C \simeq 100 + 10\,(T_S + T_N)$$

(14)
$$g_1 = 2\,(a_1 - b_1) \sin k \frac{\pi}{2} + b_1 \sin k \frac{\pi}{4}$$
$$g_2 = 2\,b_1 \sin k \frac{\pi}{6} + 5\,a_2 \sin k \frac{\pi}{8}$$
$$g_1' = 3\,B_0 \sin k \frac{\pi}{3} - a_2 \sin k \frac{\pi}{4}$$
$$g_2' = 3\,a_1 \sin k \frac{\pi}{4} + 2\,b_0 \sin k \frac{\pi}{6}$$

and a_1, a_2, b_0, b_1, b_2 and B are given by relations (9).

The sum $T_S + T_N$ is always contained between 6 and 12 years i.e.

$$6 \leq T_S + T_N < 12$$

Therefore the quantity $B = 100 + 10\,(T_S + T_N)$ can be replaced by a mean value, so that we can put in a first approximation:

$$\frac{10}{C} \simeq 0{,}055$$

$$\frac{A}{C} = 0{,}055 \left\{ (T_S - T_N) - 10^{-1} (T_O - T_N)^2 b_1 \right\}$$

In this way relations (12) and (13) can now be written in the following way:

a) for the cycles with even current number N

$$Q_H = 0{,}055 \{ (T_S - T_N) - 10^{-1} (T_O - T_N)^2 b_1 - g_1 \} \text{ before the maximum}$$

(10)

$$Q_H = 0{,}055 \{ (T_S - T_N) - 10^{-1} (T_O - T_N)^2 b_1 + g_2 \} \text{ after » »}$$

b) for the cycles with odd current number N

$$Q_H = 0{,}055 \{ (T_S - T_N) - 10^{-1} (T_O - T_N)^2 b_1 - g_1' \} \text{ before the maximum}$$

(16)

$$Q_H = 0{,}055 \{ (T_S - T_N) - 10^{-1} (T_O - T_N)^2 b_1 - g_2' \} \text{ after » »}$$

Relations (15) and (16) show, that during the year of maximum solar activity when $g_1 = g_2 = g_1' = g_2' = 0$ the asymmetry Q_H depends on the difference $T_S - T_N$ of the values of the time of rise corresponding to the two solar hemispheres as well as on the periodic term

$$10^{-1} (T_O - T_N)^2 b_1 = 10^{-1} (T_O - T_N)^2 \sin N \frac{2\pi}{8}$$

with a period aqual to 8 sunspot cycles, which is the same with the periodic term appearing in relation (1). During the years preceding of following the year of maximum solar activity, on the contrary, i.e. during the ascending or the descending branch of the solar activity curve, the asymmetry Q_H depends also on the periodic terms $g_{1,2}$ and $g_1'{}_{,2}$ (relations 14), the graphical representation of which is given in Fig. 2.

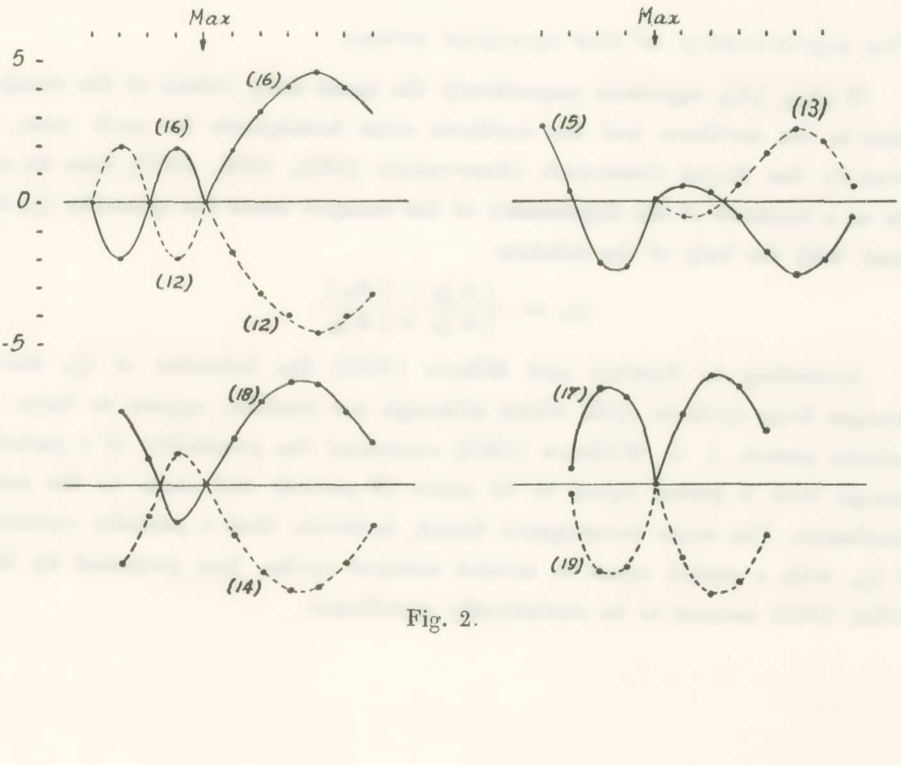

Fig. 2.

From Fig. 2 we see, that during the ascending and the descending branch of the solar activity curve we should have an inversion of the asymmetry Q_H between the even sunspot cycles No 12, 16 and 14, 18 as well as between the odd cycles 13 15 and 17 19. The observational data concerning the maximum magnetic field strength of the sunspot groups now available, are unfortunately restricted to the time interval contained between the maximum of the sunspot cycle No 15 (1917) and the maximum of the cycle No 19 (1957), and for this reason they do not allow us to verify the inversion of the asymmetry of the values of the annual sums of the maximum magnetic field strengths of the sunspot groups described above. There are, however, some indirect indications about the reality of this phaenomenon based upon the study of the asymmetry of the sunspot areas, which we are going to discuss below.

In the left part of the Fig. 3a and 3b the dashed lines represent the values of the asymmetry Q_H computed with the help of the relations (15) and (16) while the small circles give the values of this quantity found on the basis of the Mount Wilson observations for the years 1917-1958. From these figures we see, that the agreement between the observed and the computed values of the asymmetry Q_H for the years 1917-1958 (cycles No 15-19) is fairly satisfactory.

The asymmetry of the sunspot areas.

If $[A]_N$, $[A]_S$ represent respectively the mean daily values of the sunspot areas in the northern and the southern solar hemisphere for each year, as given by the Royal Greenwich Observatory (1955, 1956, 1957), then we can use as a measure of the asymmetry of the sunspot areas the quantity Q_A defined with the help of the relation

$$Q_A = \frac{[A]_N - [A_S]}{[A]_N + [A]_S}$$

According to Newton and Milsom (1955) the behavior of Q_A shows changes from cycle to cycle which although not random, appear to have no definite period. J. G. Wolbach (1962) examined the possibility of a periodic change with a period equal to 10 years (B-period) and came to the same conclusion. The same investigator found, however, that a periodic variation of Q_A with a period equal to several sunspot cycles, first proposed by Bell (1959, 1962) seemed to be statistically significant.

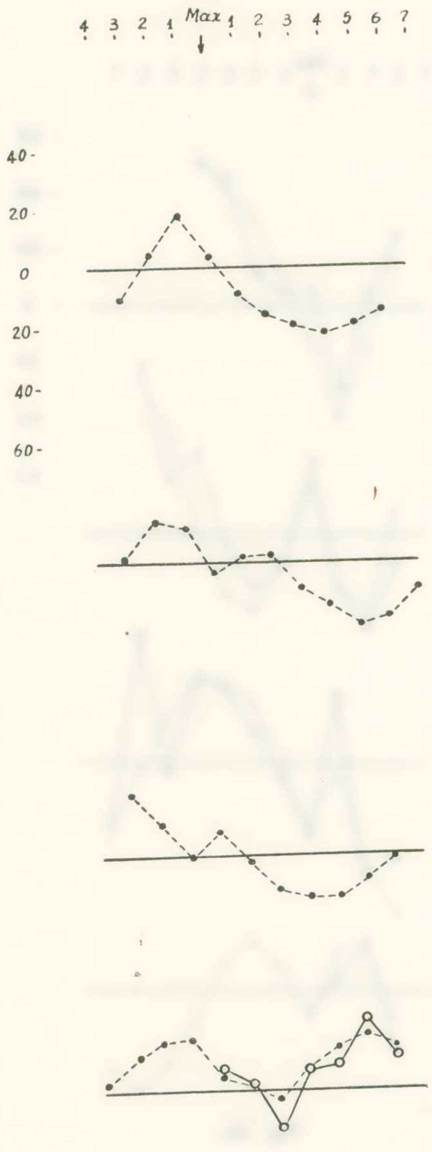
4 3 2 1 Max 1 2 3 4 5 6 7
40
20
0
20
40
60

Fig. 3a.

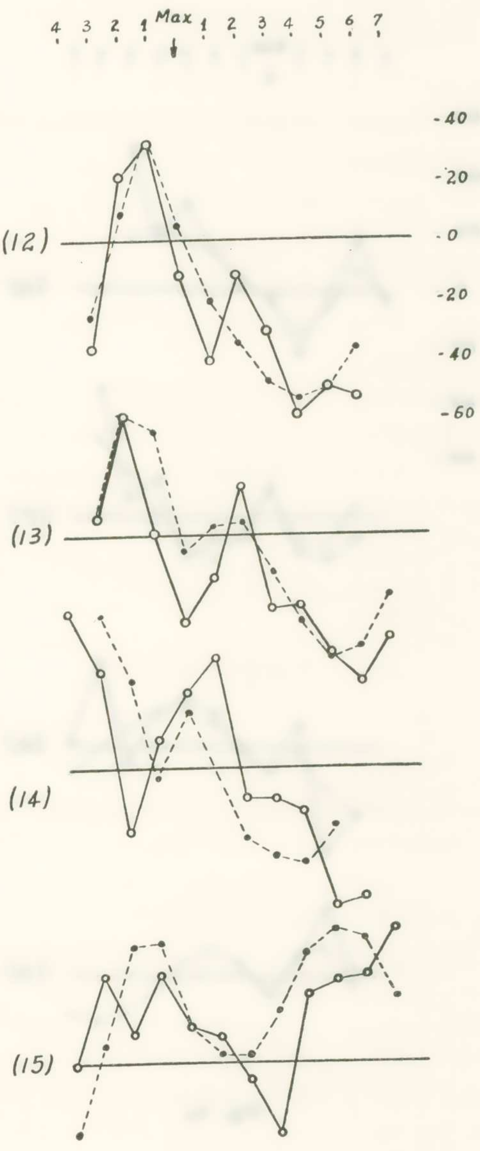
4 3 2 1 Max 1 2 3 4 5 6 7
-40
-20
-0
-20
-40
-60
(12)
(13)
(14)
(15)

Fig. 3b.

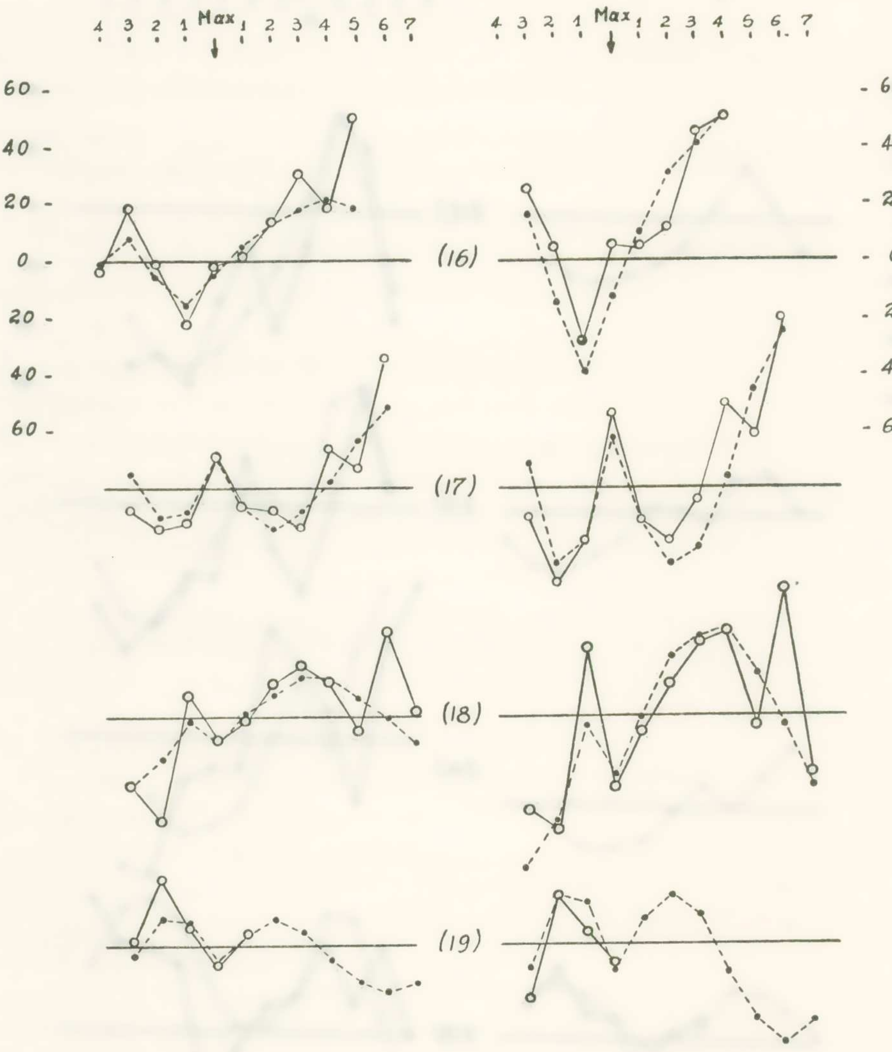

Fig. 3a.

Fig. 3b.

In previous papers (Xanthakis 1959, 1961) an effort has been made to show, that the values of the asymmetry Q_A corresponding to the cycles No 12-18 can be represented as functions of the time of rise and certain periodic terms with variable period and amplitude. A comparison of the variations of the asymmetry Q_H and the asymmetry Q_A shows now, that these two parameters change in the same general way in the cycles No 15-19, for which observational data for both of them are available, while during for the cycles No 12, 13 and 14, for which observational data for the sunspot areas but no data for the maximum values of the magnetic field strengths of the sunspot groups are available, the asymmetry Q_A of the sunspot areas presents a variation which is analogous to the variation of the values of the asymmetry Q_H computed with the help of the relations (15) and 16). These results are also shown by Fig. 3a and 3b (right part), where the small circles which are connected by continuous lines represent the values of the asymmetry Q_A of the sunspot areas, as given by the observations of the Royal Greenwich Observatory, while the dots which are connected by the dashed lines give the values of the quantity 2.2 Q_H, where Q_H represents the asymmetry of the annual sums of the maximum magnetic field strengths of the sunspot groups computed with the help of relations (15) and (16). From these figures we see, that the variation of the asymmetry of the sunspot areas Q_A during the sunspot cycles No 12-19 is analogous to the variation of the asymmetry Q_H of the annual sums of the maximum magnetic field strengths of the sunspot groups, so that we can put in a first approximation

$$Q_A = 2.2\, Q_H$$

If we exclude the years 1889, 1912, 1913 and 1933 which correspond to the minima of solar activity, for all the remaining years the agreement between the observed values of Q_A and the values of this quantity given by the above relation is fairly satisfactory, the accuracy computed with the help of the formula $(1 - \frac{\sigma}{Q_A})$ 100% being equal to 85%.

If we take into account, that according to Ringnes and Jensen (1960) there is a close relation between the strength of the magnetic field and the area of the sunspots, and if we further assume, that the variation of the asymmetry Q_H of the annual sums of the maximum magnetic field strengths of the sunspot groups is analogous to the variation of the asymmetry of the total sunspot magnetic field strengths i.e. the one computed with the help of the sums Σh, then it is reasonable to accept, that the observed asymmetry Q_A of the sunspot areas is the result of the asymmetry in the distribution of the total magnetic field strengths between the two solar hemispheres.

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ΠΕΡΙΛΗΨΙΣ

Εἰς τὴν παροῦσαν ἐργασίαν μελετῶνται αἱ ὑπὸ τῶν παρατηρήσεων τοῦ Ἀστεροσκοπείου τοῦ ὄρους Οὐΐλσων παρεχόμεναι τιμαὶ τῶν ἀθροισμάτων ΣH_N καὶ ΣH_S ἔνθα H_N καὶ H_S παριστῶσι τὰς μεγίστας τιμὰς τῆς ἐντάσεως τοῦ μαγνητικοῦ πεδίου, αἱ ὁποῖαι παρετηρήθησαν δι' ἑκάστην ὁμάδα κηλίδων κειμένην ἀντιστοίχως ἐπὶ τοῦ βορείου ἢ τοῦ νοτίου ἡμισφαιρίου τοῦ Ἡλίου κατὰ τὴν διάρκειαν ἑκάστης διαβάσεώς της διὰ τοῦ ὁρατοῦ ἡμισφαιρίου τοῦ Ἡλίου.

Διὰ τὰς ποσότητας ταύτας παρέχονται ἀναλυτικαὶ ἐκφράσεις συναρτήσει τῶν χρόνων ἀνόδου T_N καὶ T_S τῶν ἀντιστοιχούντων εἰς τὰ ἐμβαδὰ τῶν ἡλιακῶν κηλίδων. Τῇ βοηθείᾳ τῶν ἀναλυτικῶν τούτων σχέσεων μελετᾶται ἐν συνεχείᾳ ἡ ἀσυμμετρία N - S τῆς ἐντάσεως τοῦ μαγνητικοῦ πεδίου τῶν κηλίδων, τῆς ὁποίας ἡ πορεία εὑρίσκεται ὅτι εἶναι ἀνάλογος πρὸς τὴν πορείαν τῆς ἀσυμμετρίας N - S τῶν ἐμβαδῶν τῶν κηλίδων διὰ τοὺς ὑπ' ἀριθμ. 12 - 19 κύκλους.