Magnetic "Character" Figures: Antarctic and International

1914 Proc. Phys. Soc. London 27 193

(http://iopscience.iop.org/1478-7814/27/1/316)

XVI. *Magnetic "Character" Figures: Antarctic and International.* *By* C. Chree. *Sc.D., LL.D., F.R.S.*

Received February 2, 1915.

§ 1. Since January, 1906, an international scheme has existed for assigning to individual days magnetic "character" figures "0" (quiet), "1" (moderately disturbed), "2" (highly disturbed). These figures have been assigned independently at each co-operating observatory, the observer taking into account only the curves of his own station. The results are sent in quarterly to the Director of De Bilt Observatory in the Netherlands, who undertakes the analysis and publication. At the year's end he issues a list ascribing to each day a "character" figure which represents the mean estimate of the co-operating stations, the results being given to 0·1. On these figures he bases the selection for each month of five "quiet" days, which are recommended for the deduction of the regular diurnal variation for international purposes. A "day" in this connection means a period of 24 hours commencing at Greenwich midnight.

For purposes of my own I have utilised the international data for the selection of the five most disturbed days of each month, regarded as the days having the largest "character" figures. Occasionally the question arises which of two days having equal "character" figures should occupy the fifth place. In such a case preference has been given to a day immediately adjacent to a highly disturbed day.

The impression produced on the mind by a magnetic trace depends a good deal on the sensitiveness of the magnetograph. With very high sensitiveness, such as 1 mm.$=1\gamma(1\times 10^{-5}$ C.G.S.) disturbances catch the eye which on an insensitive record, such as 1 mm.$=10\gamma$, seem insignificant. Some stations, again, are much more disturbed than others, while different observers have different ideals. Thus the standard differs at different observatories. What one observer accepts at once as a "2" day, another equally readily accepts as a "1". Further, as I have shown elsewhere,* one's estimate of disturbance is apt to be influenced by the presence or absence of large disturbances about the time. If one maintained an absolutely uniform standard, class "0" would be but slightly represented

* Roy. Soc., "Phil. Trans.," A. Vol. 213, p. 245.

in a disturbed season, and class "2" in a quiet season. Thus even the final international figures do not, I think, have an exact physical significance, but they do at least discriminate with very considerable accuracy between the days of the same month.

The large majority of the stations contributing to the international lists lie between 55°N. and 25°N. lat. The extreme latitudes represented are 59·7°N. (Pavlovsk) and 31·7°S. (Pilar). There are observatories further south than Pilar in British territory from which figures would be valuable.

There is a great difference magnetically between stations in moderate and high latitudes. At all stations, so far as I am aware, which have been occupied within the Arctic or Antartic circle, magnetic disturbances have shown a persistence and amplitude unparalleled in temperate or torrid zones. There are grounds for believing a connection between magnetic disturbances and auroras of a rapidly oscillating type. The frequency of aurora in Europe diminishes rapidly as one moves southwards from the auroral belt. Auroras are frequent occurrences as far south as Shetland, but very rare in southern England. According to Prof. Kr. Birkeland's* theory, which has a good deal to say for itself, auroras and magnetic storms are alike due to flights of electric ions discharged from the sun. When these ions enter the earth's magnetic field they describe spirals round the lines of force, and none which do not possess an exceptionally high velocity, closely approaching that of light, can get near the earth, except within a moderate angular distance of the magnetic poles. There may thus be an almost continuous advent of ions with consequent aurora in high latitudes, and but very occasional advent in temperate latitudes. The disturbance due to the ions present in high latitudes is, of course, not *wholly* limited to these latitudes, but only faint effects would ordinarily be experienced in remote regions. On this view there need be no close connection between the prevalence of disturbance in mid-Europe and in high latitudes, especially high southern latitudes. Unless on the relatively few occasions when numerous ions of high velocity are discharged from the sun, there are also unusually copious discharges of the slower moving ions, the presence of a magnetic storm in central and southern Europe would not necessarily

* "Expédition Norvégienne, 1899-1900." "The Norwegian Aurora Polaris Expedition, 1902-1903," Vol. I., Sects. I. & II. Also numerous Papers in the "Comptes Rendus" of the French Academy since 1908.

imply any special disturbance in the Arctic and Antarctic. Conversely, the presence of quiet conditions in mid-Europe would raise but a slight presumption of quiet conditions in high latitudes. Thus theoretical as well as practical considerations indicated the desirability of examining the records obtained during Captain Scott's last Antarctic Expedition, to see whether there is any marked connection between the magnetic "character" of days in high and moderate latitudes. It was also investigated whether the so-called 27-day period manifests itself in the Antarctic.

§ 2. In previous investigations* of the 27-day period I have employed two sets of magnetic data, viz., the absolute daily ranges of the magnetic elements and "character" figures, either the international figures published at De Bilt, or figures assigned by myself to Kew curves, for years for which no international data exist. Absolute daily ranges have been got out for the Antarctic curves, but they refer to days in the local time of 180° longitude, and the additional labour necessary to determine a second set of ranges applicable to days G.M.T. hardly seemed justified. Thus I decided to assign and employ "character" figures.

Thanks to the assiduous care of the Antarctic magnetic observers, Dr. G. C. Simpson and Mr. C. S. Wright, there are but few gaps in the record extending from the beginning of February, 1911, to near the end of November, 1912. There were, however, a few days on which the loss of trace rendered it impossible to assign a "character" figure satisfactorily. A few hours' trace may justify one in assigning a "2," but unless the day's trace is very nearly complete it is hardly safe to assign a "0."

Table I. gives the dates of the five most disturbed and the five international quiet days of each month, along with the corresponding "character" figures assigned by myself to the Antarctic curves. A few days are left blank for the reason stated above. The "character" figures are taken from a list including all days for which adequate Antarctic records existed. When making the estimate I did not consult the international list, so there was no possible prejudice. Before actually assigning the figures, I made a general inspection of all the Antarctic curves, so as to set myself a standard of disturbance likely to discriminate adequately between the days of all the

* Roy. Soc. "Trans." A. Vol. 212, p. 75; Vol. 213, p. 245; "Proc." A, Vol. 90, p. 583.

months. If I had applied such a standard as is applied to Kew curves, most of the summer months would have received no 0's and very few 1's. Even as it is, the number of 2's allotted is much greater than at the average station co-operating in the international scheme.

TABLE I.—*Antarctic "Character" Figures on International Disturbed and Quiet Days.*

	Dates.										Antarctic character figures.									
1911.	Disturbed days.					Quiet days.					Disturbed days.					Quiet days.				
February ...	2	13	21	22	23	11	12	15	19	20	2	2	2	2	2	1	1	1	1	0
March	20	21	23	25	26	10	11	12	17	18	2	2	2	2	2	0	0	0	1	0
April	8	9	16	17	30	5	13	14	15	26	2	2	2	2	2	0	–	0	1	1
May	7	14	15	16	31	1	4	13	22	24	2	2	2	2	2	0	0	0	1	0
June	4	5	9	10	11	3	17	18	19	25	1	2	1	2	1	1	0	0	0	0
July	1	17	19	28	29	13	14	15	16	26	2	1	2	2	2	1	1	0	1	0
August	19	23	24	25	26	7	8	10	11	29	2	2	2	2	2	1	0	1	0	1
September .	16	19	20	21	22	2	3	14	25	26	2	1	2	2	2	1	0	1	0	1
October	9	10	11	17	18	1	5	15	23	28	2	2	2	2	2	0	0	2	1	1
November...	3	9	13	14	15	1	7	22	23	24	2	2	2	2	2	1	1	1	1	1
December...	6	11	17	26	31	2	9	21	22	23	2	2	2	2	2	2	0	2	1	2
1912.																				
January	11	12	13	17	22	2	15	16	26	27	1	2	2	2	2	1	1	1	1	0
February ...	12	13	16	17	26	5	6	15	20	21	2	1	1	2	–	0	1	1	1	0
March	7	8	9	21	29	4	17	18	19	24	1	2	1	1	1	0	0	0	0	1
April	5	6	10	15	16	1	8	11	21	28	2	2	2	2	2	0	0	0	0	0
May	5	6	12	13	14	1	16	22	23	26	2	1	2	2	2	1	0	0	0	1
June	1	8	9	10	28	5	6	15	19	20	2	2	2	2	1	0	1	0	0	0
July	3	4	5	27	31	10	11	12	15	24	1	2	2	1	1	0	0	0	0	0
August	5	6	18	19	22	4	8	12	13	26	1	1	2	2	2	0	0	0	0	1
September .	4	17	18	23	24	2	15	16	27	28	1	2	2	1	2	0	0	1	0	0
October	1	11	13	14	15	2	5	18	19	31	2	2	1	2	2	1	1	1	0	1
November...	10	11	14	16	22	3	12	21	29	30	2	2	–	2	–	1	1	–	–	–

A glance at Table I. shows that the association between Antarctic disturbances and those in moderate latitudes was very intimate. Of the 107 international highly disturbed days for which Antarctic records existed, 85 got a "2," and not a single one a "0." Only one day which had an international "character" figure as large as 1·3 failed to get a "2," and it was a day on which several hours' trace was missing, so that allotting it a "1," as I did, was rather a rash proceeding. On the other hand, 57 of the 106 international "quiet" days got a "0" and only four got a "2." Of these, three occurred in December, 1911, a month to which I allotted sixteen 2's and only one 0. Moreover, all three were essentially quiet except for a few hours near midnight, and the disturbance was so moderate that it was open to doubt whether a "1" or a "2" was fairer.

The fourth international quiet day which got a "2" was also close to the border line between "1" and "2." In only one of the four cases was there any suggestion from the international data that there had been a disturbance peculiar to high latitudes. On that occasion a "1" had been allotted at Pilar, the most southern station, and at Sitka, one of the most northern, every other station with one exception assigning a "0."

§ 3. Various other interesting conclusions could be derived from Table I., but they are more readily recognised in Table II., which analyses the data from the different months. The Antarctic selected disturbed and quiet day data for November, 1912, were derived from only three disturbed and two quiet days, and only 15 days were available altogether, so the results for that month are somewhat uncertain.

TABLE II.—*Mean Monthly and Annual "Character" Figures.*

—	1911.						1912.					
	International.			Antarctic.			International.			Antarctic.		
	Dist.	All.	Quiet.	Dist.	All.	Quiet.	Dist.	All.	Quiet.	Dist.	All.	Quiet.
January	...	...	...	...	...	...	0·98	0·42	0·02	1·8	1·26	0·8
February	1·46	0·89	0·36	2·0	1·54	0·8	1·02	0·49	0·12	1·5	1·00	0·6
March	1·48	0·78	0·08	2·0	1·26	0·2	1·08	0·45	0·02	1·2	0·83	0·2
April	1·48	0·76	0·14	2·0	1·28	0·5	1·12	0·45	0·08	2·0	0·73	0·0
May	1·28	0·70	0·16	2·0	1·23	0·2	1·18	0·47	0·10	1·8	0·77	0·4
June	1·12	0·53	0·04	1·4	1·00	0·2	0·98	0·47	0·08	1·8	0·86	0·2
July	1·26	0·61	0·12	1·8	1·32	0·6	1·06	0·41	0·02	1·4	0·70	0·0
August	1·30	0·53	0·10	2·0	1·06	0·6	1·12	0·49	0·02	1·6	1·03	0·2
September	1·30	0·50	0·06	1·8	0·97	0·6	1·22	0·47	0·02	1·6	0·97	0·2
October	1·30	0·59	0·06	2·0	1·26	0·8	1·20	·046	0·02	1·8	1·23	0·8
November	1·42	0·49	0·04	2·0	1·47	1·0	1·06	0·45	0·00	2·0	1·53	1·0
December	1·30	0·45	0·08	2·0	1·48	1·4	...	...	...	...	...	...
Means	1·34	0·62	0·11	1·91	1·26	0·63	1·09	0·46	0·04	1·68	0·99	0·40

As already indicated, the necessity of discriminating adequately between the different days of the same month tends to variation in the international standard, of such a nature as to minimise the difference between different years. The fall in disturbance, however, between 1911 and 1912 was so large that it is readily recognised in the international figures in Table II., whether one regards the disturbed day, the quiet day, or the all-day results. There is also, it will be seen, a marked decline in the Antarctic "character" figures. Thus in this case, at least, the fall in disturbance was common to high and temperate latitudes. According to statistics advanced by some authorities, auroras have been more numerous at stations to the north of the Arctic aurora belt during years in which they have been less numerous at stations to the south of it. Thus it would not have been safe to assume *a priori* that disturbances near a magnetic pole and those in temperate latitudes wax and wane together.

Another phenomenon clearly visible in Table II. seems peculiar to the Antarctic. In temperate latitudes disturbance is most prominent towards the equinoxes. In the Antarctic the equinoctial months, while decidedly more disturbed than the winter months, are less disturbed than the summer months. This phenomenon was also clearly shown by the magnetic curves obtained in 1902 and 1903 by the first Scott Antarctic Expedition.

TABLE III.—*Antarctic "Character" Figures. Sums on Selected and Associated Days.*

	$n-2$	$n-1$	n	$n+1$	$n+2$	$n+25$	$n+26$	$n+27$	$n+28$	$n+29$	$n+30$
Disturbed and associated days:											
1911 (55 days)	55	76	106	98	88	63	72	83	90	85	76
1912 (49 ,,)	44	58	81	72	53	48	55	64	57	56	45
Total (104 days)	99	134	187	170	141	111	127	147	147	141	121
Quiet and Associated days:											
1911 (55 days)	67	54	35	46	66	65	50	47	54	67	74
1912 (49 ,,)	42	35	16	31	44	37	41	41	44	49	50
Total (104 days)	109	89	51	77	110	102	91	88	98	116	124
Disturbed and associated, less quiet and associated:											
1911 (55 days)	−12	+22	+71	+52	+22	− 2	+22	+36	+36	+18	+ 2
1912 (49 ,,)	+ 2	+23	+65	+41	+ 9	+11	+14	+23	+13	+ 7	− 5
Total (104 days)	−10	+45	+136	+93	+31	+ 9	+36	+59	+49	+25	− 3

§ 4. In order to ascertain whether the 27-day period is recognisable in the Antarctic, the "character" figures which had been assigned were entered in tables of which Table III. constitutes a summary, in columns headed $n-2$ to $n+2$ and $n+25$ to $n+30$. Here n stands for a representative selected day, whether one of the five disturbed or one of the five international quiet days of the month, $n-1$ and $n+1$ represent the days immediately preceding and succeeding, $n+25$ the day 25 days later, and so on. None of the selected days for November, 1912, appeared in column n because there were no corresponding data for columns $n+25$ to $n+30$. What appears in Table III. is the *sum* of the "character" figures, allowance being made for one or more days missing in some of the columns. For instance, in 1912, in the case of the disturbed and associated days, only 48 days' "character" figures were really available for column $n+2$. Their sum 52 was brought up to 53, as the integer nearest to $(49/48)\times 52$.

The 27-day period is clearly shown in the case alike of the disturbed and the quiet days, and still more clearly in the difference figures, obtained by substracting the totals for the quiet and associated days from the corresponding totals for the disturbed and associated davs

A similar procedure was applied to days that were from 30 to 25 days earlier than the selected disturbed and quiet days. In this case the selected days of February, 1911, could not be utilised. Table IV. gives the results obtained for the columns n—30 to n—25. The results for the columns n—2 to $n+2$ differed so little from the analogous results in Table III. that it seemed unnecessary to give them. While Table III. suggests a period distinctly longer than 27 days, Table IV. would make the period more nearly 26 days. This is not improbably connected with the lack of symmetry which Table III. discloses in the primary pulse. The "character" sum in column $n+1$ is greater for disturbed and less for quiet days than the corresponding "character" sum in column n—1. Thus the centre of the primary pulse would seem to fall well after the middle of the representative selected day.

TABLE IV.—*Antarctic "Character" Figures. Sums on Associated Days.*

	$n-30$	$n-29$	$n-28$	$n-27$	$n-26$	$n-25$
Disturbed associated days:						
1911 (50 days)	49	51	67	79	84	80
1912 (55 ,,)	61	56	55	67	70	67
Total (105 days)................	110	107	122	146	154	147
Quiet associated days:						
1911 (50 days)	64	60	54	48	47	51
1912 (55 ,,)	57	51	47	49	49	47
Total (105 days)................	121	111	101	97	96	98
Disturbed associated less quiet associated (105 days)..........	−11	− 4	+21	+49	+58	+49

Table V. employs the same data as Table III., but arranges them under three seasons, viz., winter (May to August), summer (November to February) and equinox (the remaining four months). The 27-day period is apparent in each season, but is less well marked in summer than in winter or equinox. This is partly explained by the smaller number of days available in summer, and partly by the fact that disturbances at that season were so large and numerous that the number of "character" 0's allotted was hardly sufficient to discriminate adequately between the days of the same month.

The sun, it should be remarked, was continuously above the horizon almost the whole of summer, and continuously below the horizon almost the whole of winter. Its being below the horizon during the latter season seems not to have militated in any way against the 27-day period.

TABLE V.—*Antarctic "Character" Figures. Sums on Selected and Associated Days.*

	$n-2$	$n-1$	n	$n+1$	$n+2$	$n+25$	$n+26$	$n+27$	$n+28$	$n+29$	$n+30$
Winter, 40 days { Dist., &c.	37	50	69	64	51	40	49	57	57	51	41
Winter, 40 days { Quiet, &c	34	25	12	23	31	34	26	25	34	37	39
Excess of dist'bd, &c.	+ 3	+25	+57	+41	+20	+ 6	+23	+32	+23	+14	+ 2
Equinox, 40 days { Dist., &c.	36	50	72	64	57	45	48	59	59	61	53
Equinox, 40 days { Quiet, &c.	42	34	16	25	42	40	39	39	42	51	53
Excess of dist'bd, &c.	− 6	+16	+56	+39	+15	+ 5	+ 9	+20	+17	+10	0
Summer, 25 days { Dist., &c.	27	35	47	44	34	27	31	32	32	30	28
Summer, 25 days { Quiet, &c.	34	31	23	30	38	29	27	25	23	29	33
Excess of dist'bd, &c.	− 7	+ 4	+24	+14	− 4	− 2	+ 4	+ 7	+ 9	+ 1	− 5

§ 5. The mean of the Antarctic "character" figures, notwithstanding the much higher standard of disturbance employed, was much in excess of the corresponding international mean. Thus it appeared desirable for purposes of comparison to express the results as percentages of some standard value. Two quantities suggested themselves as standards, 1° the mean "character" figure from all days of the year, and 2° the amplitude of the primary pulse, *i.e.*, the excess of the "character" figure of the representative disturbed day over that of the representative quiet day of the year. Both have been used. The Antarctic data referred to both standards are given in Table VI. The international data referred to the two standards appear separately in Tables VII. and VIII. These two last tables are not confined to 1911 and 1912, but include all the years for which international data have been published.

To explain the figures, consider the Antarctic results for 1911 in Table VI. The mean "character" figure for 1911 was 1·26. There were 55 selected disturbed and 55 selected quiet days. The sum of the "character" figures for 55 average days is 55×1·26 or 69·3. The sums for the 55 selected days were respectively: disturbed 106, quiet 35. The difference of these sums—or amplitude of the primary pulse—71, expressed as a percentage of 69·3, is to the nearest integer 102. The sums for the 55 days which followed 27 days after the selected days were respectively: associated disturbed days 83, associated quiet days 47, and again to the nearest integer 100 (83—47)/69·3=52.

The figures in the second line of Table VI. were got in an exactly similar way, using as standard 0·99, the mean "character" figure for 1912.

TABLE VI.—*Antarctic "Character" Figures. Differences Disturbed and Associated Days less Quiet and Associated Days as percentages.*

		$n-2$	$n-1$	n	$n+1$	$n+2$	$n+25$	$n+26$	$n+27$	$n+28$	$n+29$	$n+30$
As percentages of mean character figure for year	1911	−17	+32	+102	+75	+32	− 3	+32	+52	+52	+26	+ 3
	1912	+ 4	+47	+134	+85	+19	+23	+29	+47	+27	+14	−10
	Mean	− 7	+40	+118	+80	+25	+10	+30	+50	+39	+20	− 4
As percentages of difference dist. less quiet on day n	1911	−17	+31	+100	+73	+31	− 3	+31	+51	+51	+25	+ 3
	1912	+ 3	+35	+100	+63	+14	+17	+21	+35	+20	+11	− 8
	Mean	− 7	+33	+100	+68	+22	+ 7	+26	+43	+35	+18	− 3

TABLE VII.—*International "Character" Figures. Differences Disturbed and Associated Days less Quiet and Associated Days as percentages of Mean "Character" Figure for Year.*

Year.	$n-2$	$n-1$	n	$n+1$	$n+2$	$n+25$	$n+26$	$n+27$	$n+28$	$n+29$	$n+30$
1906	22	92	179	96	15	6	37	47	24	7	−16
1907	17	96	179	83	2	8	31	31	17	18	29
1908	14	94	175	98	17	27	60	57	44	15	− 2
1909	29	94	195	103	25	−15	0	37	41	35	17
1910	21	83	161	80	18	5	37	56	47	22	6
1911	10	86	189	93	16	26	65	89	69	21	2
1912	0	98	233	109	−18	17	48	69	18	−14	−16
1913	52	131	228	118	40	59	88	98	62	46	34
Mean	20·6	96·7	192·5	97·5	14·5	16·7	45·7	60·4	40·3	18·7	6·8

TABLE VIII.—*International "Character" Figures. Differences Disturbed and Associated Days less Quiet and Associated Days as percentages of Difference on Day n.*

Year.	$n-2$	$n-1$	n	$n+1$	$n+2$	$n+25$	$n+26$	$n+27$	$n+28$	$n+29$	$n+30$
1906	12	51	100	54	9	4	20	26	14	4	− 9
1907	10	53	100	46	1	4	17	17	10	10	16
1908	8	53	100	56	10	15	34	33	25	8	− 1
1909	15	48	100	53	13	− 7	0	19	21	18	9
1910	13	52	100	49	11	3	23	34	29	13	4
1911	5	46	100	49	9	14	35	47	36	11	1
1912	0	42	100	47	− 8	7	21	30	8	− 6	− 7
1913	23	57	100	52	18	26	39	43	27	20	15
Mean	10·7	50·4	100	50·8	7·7	8·2	23·6	31·1	21·2	9·9	3·5

As regards the second set of percentages in Table VI., we have already seen that the amplitude of the primary pulse for 1911 was 106—35, or 71. In column $n+27$, for example, for 1911 we have $100(83-47)/71=51$ to the nearest integer. The percentage figures for the individual years in Tables VI., VII. and VIII. were all calculated to one figure beyond that recorded, and these more exact figures were employed in deducing the final means given in the tables.

Fig. 1 shows separately the primary and secondary pulses for disturbed and associated and for quiet and associated days, the numerical data represented being the percentages whose difference appears in the last line of Table VII.

Fig. 2 shows the primary and secondary difference pulses derived from the Antarctic data in the last line of Table VI. and from international "character" data in Table VIII. The sunspot maximum group of years 1906, 1907 and 1908 had a mean sunspot frequency of 53·8, while the sunspot minimum group 1911, 1912 and 1913 had a frequency of 3·5.

The numerals attached to the observational points in both figures denote the number of days from the crest (marked 0) of the primary pulse, time previous being measured to the left and time subsequent to the right. In Fig. 2 each crest 0 is at the same height above its zero line, and corresponding primary and secondary pulses and their common zero line are represented by a common type of line.

Tables VII. and VIII. show that even when data from a large number of stations are combined, the prominence of the 27-day period varies a good deal from year to year. Data from a single station are naturally exposed to greater uncertainties, but it seems a pretty safe inference from Table VI. and Fig. 2, that the 27-day period is as prominent in the Antarctic as elsewhere.

Either set of results in Table VI. makes the 27-day period more prominent in 1911 than in 1912, agreeing in this with the international figures. This is one of the reasons for including other years in Tables VII. and VIII. In the absence of evidence to the contrary, the lesser devélopment of the 27-day period in 1912

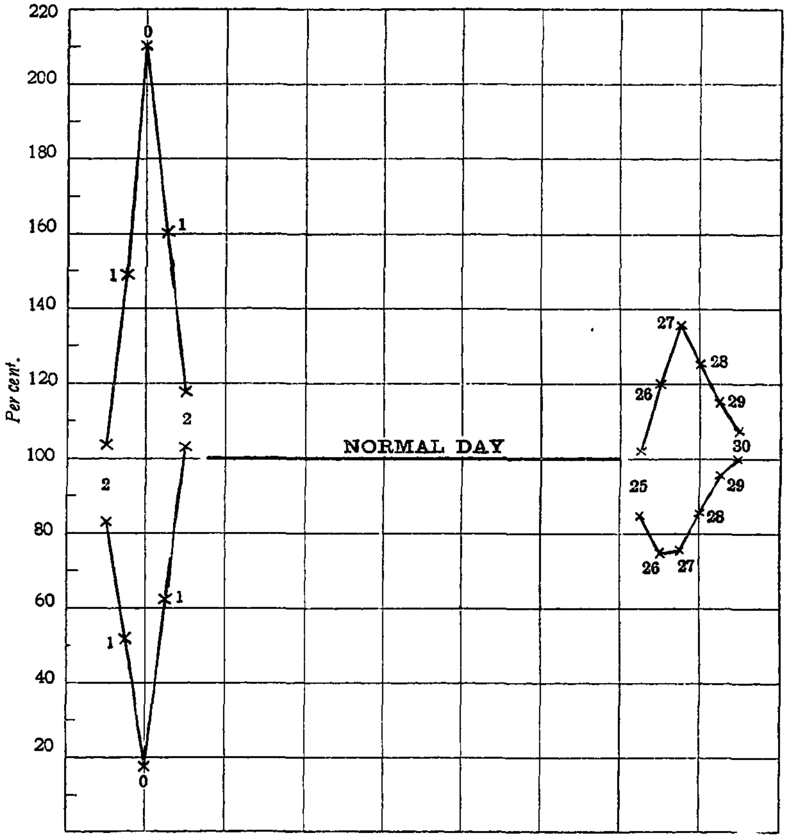

FIG. 1.—27-DAY PERIOD IN INTERNATIONAL "CHARACTER" FIGURES DISTURBED AND QUIET DAY PULSES.

might have been ascribed to the fact that that year was near sunspot minimum. On Prof. Birkeland's* theory this would seem a very natural inference. It appears, however, from Tables VII. and VIII. that the period was more developed in

* In some of his writings on the subject Prof. Birkeland seems to identify sunspots with the sources of the electrical discharges to which he ascribes magnetic storms. In others, *e.g.*, "The Norwegian Aurora Polaris Expedition, 1902-1903," Vol. I., Sect. II., p. 525, he seems to go no further than the conclusion "*that sun spots and magnetic storms are both of them manifestations of the same primary cause.*"

1912 than in either 1907 or 1909, the former a year of sunspot maximum, while less developed than in 1913 which had even fewer sunspots. It is also more prominent in the curve for

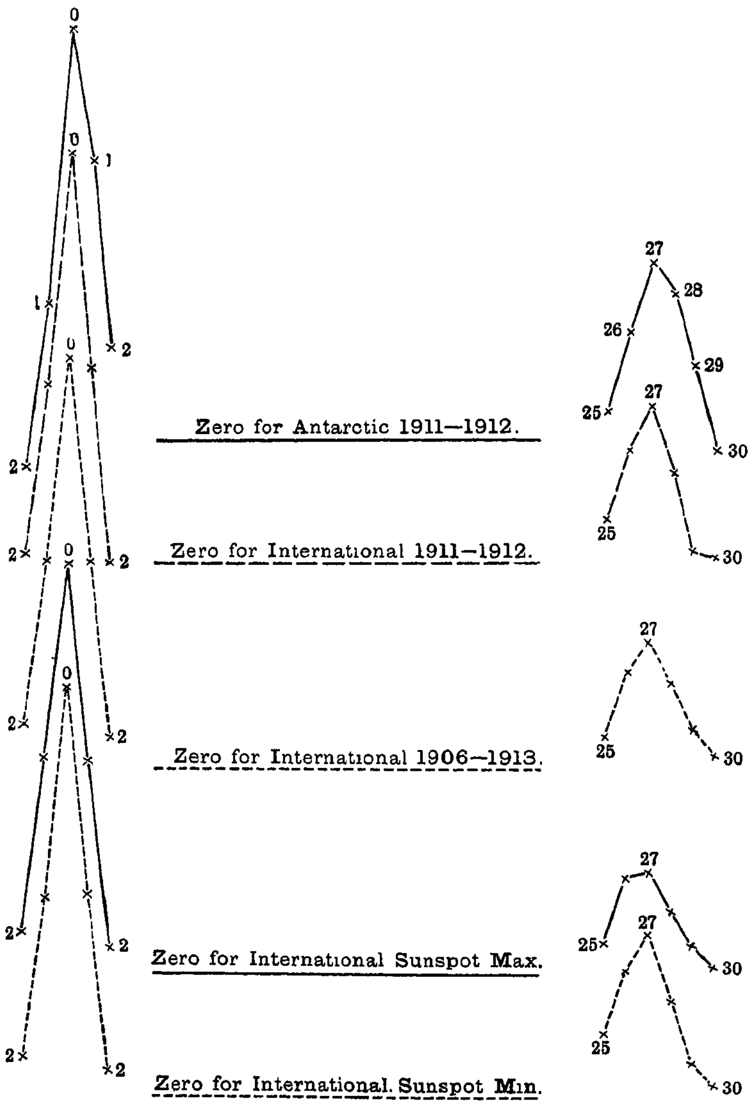

FIG. 2.—THE "27-DAY" PERIOD. "CHARACTER" FIGURES (DIFFERENCES).

sunspot minimum years than in that for sunspot maximum years in Fig. 2.

§ 6. The question seemed of sufficient interest to call for a further investigation, the results of which appear in Table IX. This gives the number of occasions on which a 27-day interval intervened between selected days, disturbed and quiet. The last column gives Wolfer's sunspot frequency. The frequency assigned to 1913 is still only "provisional," but Wolfer's provisional values seldom differ much from his final values.*

Antecedents to selected days in January, 1906, fell outside the range of international figures, thus 95 months only were available. If five random days had been selected from each month the probable number of sequences of any one species would have been 78, or roughly 10 a year. Thus the number of disturbed-disturbed sequences (*i.e.*, the number of occasions on which an interval of 27 days presented itself between two selected disturbed days) is nearly double the mathematical expectation. While these sequences are well represented in 1907, the year of sunspot maximum, they are even more numerous in 1911 and 1913 when sunspots were nearly absent.

The quiet-quiet day sequences exceed the disturbed-disturbed in four years out of the eight, but on the whole are distinctly less numerous. They are especially prominent in 1906 and 1910, years neither of sunspot maximum nor minimum. Their aggregate is no less than three times that of the disturbed-quiet sequences. The disturbed-quiet and quiet-disturbed sequences are practically equal in number.

Table IX. agrees with Tables VII. and VIII. in showing no special development of the 27-day period in years of many sunspots.

TABLE IX.—*Number of 27-day Sequences.*

First day……	Disturbed.	Quiet.	Disturbed.	Quiet.	Wolfer's sunspot frequency.
Second day…	Disturbed.	Quiet.	Quiet.	Disturbed.	
Year.					
1906	13	25	6	4	53·8
1907	19	10	9	4	62·0
1908	17	18	4	2	48·5
1909	15	17	8	11	43·9
1910	17	21	5	5	18·6
1911	25	18	5	5	5·7
1912	18	8	5	9	3·6
1913	28	15	2	3	1·2
Totals …….	152	132	44	43	…

* Since this was written Wolfer's final value has been published. This entails the substitution of 1·4 for 1·2 in the value for 1913 in Table IX., and of 3·6 for 3·5 in the mean value for the sunspot minimum years 1911, 1912 and 1913.

ABSTRACT.

The Paper makes use of magnetic " character " figures " 0 " (quiet day), " 1 " (moderately disturbed day), " 2 " (highly disturbed day) to investigate whether the incidence of disturbance at the base station of the Scott Antarctic Expedition, 1911-1912, did or did not accord with the incidence of disturbance in temperate latitudes; also whether the "27-day period " could be recognised in the Antarctic data.

A very complete set of magnetic curves was obtained by the physical observers of the Antarctic Expedition, Dr. G. C. Simpson and Mr. C. S. Wright, extending from February, 1911, to November, 1912. " Character " figures were assigned to each day's records by the author, and a comparison was made with the corresponding international figures published annually at De Bilt, Netherlands.

The incidence of disturbance in the Antarctic was found to agree closely with that shown by the international lists, in spite of the fact that the disturbances in the Antarctic were much larger and more persistent than at any of the stations co-operating in the international scheme.

The " 27-day period " was clearly visible in the Antarctic records both in summer and winter, being as well developed there as elsewhere.

DISCUSSION.

Mr. DUDDELL thought the Paper very interesting. It was only by patient investigation of this kind that we should get any nearer a comprehensive theory of terrestrial magnetism.

Mr. F. E. SMITH remarked that it was described as " clearly visible " from Table II. that the disturbances were more pronounced in temperate latitudes during the equinoctial periods than in the intervening months. This was hardly obvious to the casual observer.

Prof. J. W. NICHOLSON said that Dr. Chree's Paper made the position of Birkeland's theory more curious than ever. Leaving out of consideration, as indisputable, the mathematical difficulties of the theory which Dr. Chree had referred to, he would like to indicate one point in which the theory had some support. If we were receiving particles from the sun, some might come from the corona, and might show themselves in the coronal spectrum and, later, in that of the aurora. There was, in fact, a strong correspondence between these spectra in some important particulars, and it does seem probable that we receive such particles. It is possible that the corona actually consists of the particles which are being shot from the sun and which we receive. But the spectra of sunspots are not in accordance with the view that we receive an unusual number from the spots.

Prof. O. W. RICHARDSON thought that in the case of particles streaming through the corona the auroral spectrum would be that of the atmosphere, and not that of the exciting particles. Only electrons should really be effective in reaching the earth under the proper conditions for the aurora.

Prof. NICHOLSON said that the correspondence in spectra would only be expected if the emitted particles were the corona itself, and not merely something passing through it. We do seem, as far as the evidence is trustworthy—the auroral spectrum being somewhat unreliable—to be receiving particles heavier than electrons, whether these are really responsible for the aurora or not.

Dr. A. RUSSELL said that in the Antarctic the disturbances seemed less violent in winter than in summer, and it would be of interest to know if a similar relation held in the Arctic.

Dr. C. Chree, in reply, said that it should be remembered that in the Antarctic the midsummer months were December, January and February. The values for these months stand out more highly. Birkeland is not definite on the question as to whether sunspots are the origin of the ions or not. One reason for associating them with sunspots is that in sunspot minima the magnetic disturbances are not pronounced, but what one fails to find is an equivalent excess of disturbance during sunspot maxima.