ON THE DECREASES OF THE COSMIC-RAY INTENSITY ASSOCIATED WITH THE MAGNETIC STORMS (1)

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磁気嵐時に於ける宇宙線強度の減少について (1)

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1. Introduction

It has been reported by several investigators[1-4] that the cosmic-ray intensity generally decreases at the time of the magnetic storms. From these and other reports it is evident that the decreases of the cosmic-ray intensity, in general, considerably correlate with the changes in the horizontal intensity of the earth's field at the time of the magnetic storms and it is considered that the decreases commence about the onset-time (T_m) of the main phase of the storms. On the contrary, it has been also reported[5] that a magnetic storm which was not accompanied by any significant change in cosmic-ray intensity happened and yet the magnitude of the storm was comparable with the one which was accompanied by it.

As yet no one truly knows what kind of the magnetic storm causes a decrease in cosmic-ray intensity and what another kind of it doesn't. Even in the cases which the cosmic-ray intensity decreases any reliable correlations between $\triangle$H and $\triangle$I (the decreaments of cosmic-ray intensity associated with the magnetic storms) seem not to be obtained. On the contrary, it has been reported even that any regular relations between them seem not to exist.

But from the review of many investigators' results it is supposed that some regular relations between $\triangle$H and $\triangle$I seem to have to exist willy-nilly. But, as are pointed out by several investigators,[6] it is likely to be certain that there is no simple connexion between them. From some typical examples[7] which the sharp decrease of the cosmic-ray intensity begins to appear clearly from about the onset-time (T_m) of the main phase of the storm, it is supposed that any correlations between $\triangle$H and $\triangle$I are likely to exist by the medium of this time.

I tried to seek for the correlations by the data ready to hand from the point of such view. A survey of the correlations is given in the following paragraphs.

2. Date used

Data of the earth's magnetic field used here are as follows:

(a) The records[8] (1948-1952) of the kakioka Magnetic Observatory (36°N, 140°E.). ··· ··········· "data (a)".

(b) The geomagnetic data[9] (1941-1950) of the Huancayo Magnetic Observatory. ········ ··········· "data (b)".

(c) The geomagnetic data[10] (1940-1951) of the Cheltenham Magnetic Observatory.……………… "data (c)".

Data of the cosmic-ray intensity used here and the locations and equipments of the observatories are shown in Table 1 and Table 2 respectively.

Table 1

Observatory	Data				Reference
	Component*	Value**	Name	Period	
Tokyo	T	H	Data (A_1)	1949 - 1952	(11)
	T	D	Data (A_2)	1948 - 1952	(12)
Huancayo	T	D	Data (B_1)	1941 - 1946	(13)
	T	D	Data (C)	1950	(14)
Cheltenham	T	D	Data (B_2)	1940 - 1946	(15)
	T	D	Data (D)	1950 - 1951	(16)

* T : Total component.

** H : Hourly values, corrected for the barometer effect.

D : Daily mean.

Table 2

Station	Geomagnetic latitude	Geomagnetic longitude	Altitude m	Equipment*
Tokyo	25°N	140°E	20	C. T.
Huancayo	1°S	75°W	3,350	I. C.
Cheltenham	50°N	77°W	72	I. C.

* C. T. : Counter telescope, I. C. : Ion chamber.

3. The statistical treatment of the data and the results obtained

I treated statistically these data as follows:

I evaluated the decrements ($\triangle I$) of the cosmic-ray intensity associated with the changes ($\triangle H$) in the horizontal intensity of the earth's field at the time of the magnetic storms by using the above-mentioned cosmic-ray data and the corresponding geomagnetic data, where $\triangle H$ is the range (H) itself which has been reported by each observatory, at the time of the magnetic storms. And then I calculated each value of $\triangle I/\triangle H$ by using couples of these $\triangle I$ and $\triangle H$ due to the same storms.

If $\triangle I/\triangle H$ is plotted as a function of T_m, the diagrams of Figs. 1-5 are obtained.

In Fig. 1 and Fig. 2 the above-mentioned data(a) and data(A_1) were used and all values referred to there are shown in Table 3. In this table "T_i" indicates the time when the cosmic-ray intensity attained to minimum at the time of the magnetic storms and "$\triangle I$" the maxim-

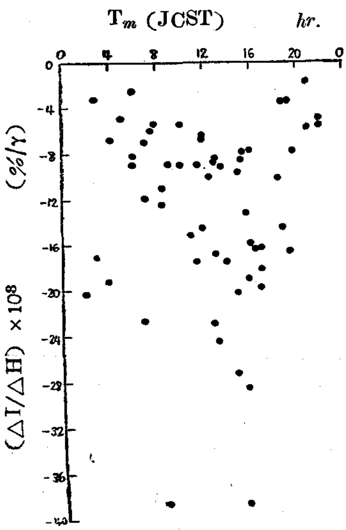

Fig. 1

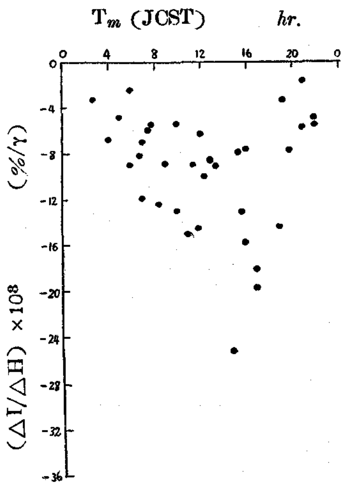

Fig. 2

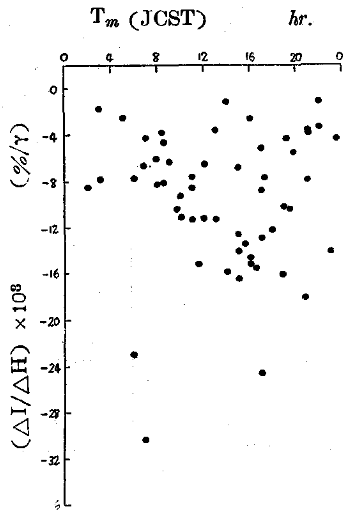

Fig. 3

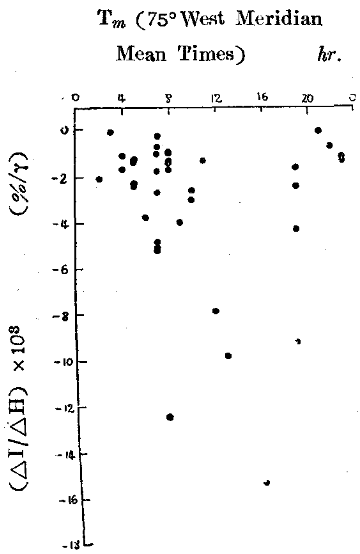

Fig. 4

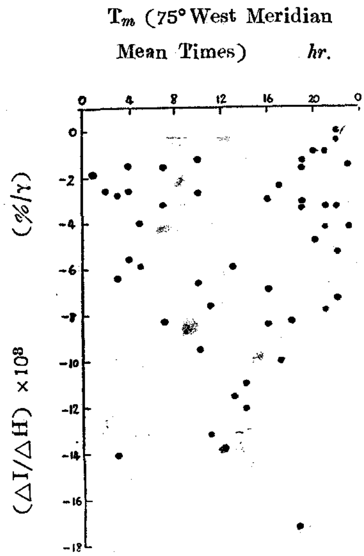

Fig. 5

Fig. 1. Correlation between $\triangle$I and $\triangle$H by the medium of T_m due to the data at Tokyo, where $\triangle$I is due to hourly values.

JCST : Japan Central Standard Time.

Fig. 2. Correlation between $\triangle$I and $\triangle$H by the medium of T_m due to the data at Tokyo, where $\triangle H \geqq 100\gamma$ and $\triangle$I is due to hourly values.

Fig. 3. Correlation between $\triangle$I and $\triangle$H by the medium of T_m due to the data at Tokyo, where $\triangle$I is due to daily mean.

Fig. 4. Correlation between $\triangle$I and $\triangle$H by the medium of T_m due to the data at Huancayo.

Fig. 5. Correlation between $\triangle$I and $\triangle$H by the medium of T_m due to the data at Cheltenham.

um deviation of the hourly values in data (A_1) from standard value (which is daily mean value during three days before the magnetic storm occurs). When evaluating the daily mean, as above, was supposed to be improper for considerably deviated values due to continuous storms, the standard value was decided by other adequated way. Besides, in the cases of evaluation of the muximum deviations, as the points of hourly values plotted pretty deviated in general, I adopted the running means and evaluated the deviations from the standard values.

In Fig. 3 geomagnetic data used were the same ones as in the cases of Fig. 1 and Fig. 2, but the data for evaluation of $\triangle I$ were data (A_2). Consequently in this case $\triangle I$ indicates the deviation of maximum decreasing value (daily mean value) of the cosmic-ray intensity from the standard value as above-mentioned. All values referred to the diagram are shown in Table 4.

In Fig. 4 and Fig. 5 data(b), data(B_1), data(C), data(c), data(B_2), and data(D) were used. All values referred to these are shown in Table 5 and Table 6. In both tables T_m indicates the time seeked by presumption from K-index tables(9) in the magazine "Terrestrial Magnetism and Atmospheric Electricity". And each time falls on the one which geomagnetic disturbance again begins to be intense (i.e. the one which K-index again becomes great) after the geomagnetic disturbance occurred about the onset-time of the magnetic storm. Of course, there sometimes occurs that the time falls on the one indicating about the onset-time of the storm. Therefore the time may be include considerable errors. $\triangle I$ in both tables indicates the value evaluated in accordance with $\triangle I$ in Table 3.

From above each diagram it is found that $\triangle I/\triangle H$ rather well depends upon T_m (is indicated by local time) and changes with a period (daily variation) and moreover the minimum value (the maximum value as for the absolute value) is attained during few hours after the noon.

4. Discussion

Though the daily variation which Figs. 1-5 indicate seems to have a opposite tendency to the familiar daily variation of the cosmic-ray intensity, in this case it is important to notice that $\triangle I$ is the decrement of the cosmic-ray intensity at the time of the magnetic storm.

At first it will be important that this $\triangle I$ is discussed. The time, T_i, when $\triangle I$ is evaluated, doesn't generally accord with T_m, but there are considerable discrepancies between them. And yet the times are the ones adopted at randam. Therefore it is supposed that the effect of the familiar daily variation of the cosmic-ray intensity enters into each value of $\triangle I$ in Table 3, whether we like it or not. Consequently there naturally occurs an anxiety that each value of $\triangle I/\triangle H$ may be affected considerably by the effect. In addition, it has been reported that during a magnetic storm there occur the particular phenomena about the cosmic-ray intensity as follows(17):

(1) The increase of the amplitude of the daily variation.

(2) The advancement of t_{max}.

Accordingly the anxiety by the effect will be great and complex more than ever.

For the exclusion of it, as y. Sekido et al.(18) did, it may be good to analyse by using the data of several observatories which lie in different latitudes, but even if the data of the only observatory are used, if a good number of the data of the storms occurring at random are chosen, this effect will be considerably offset.

On the ground of the view-point Figs. 1–2 are the diagrams plotted by using the data including fairly many storms. Accordingly it is supposed that the tendency which the diagrams indicate is not the one due to the daily variation.

If $\triangle I$ evaluated from daily mean values, instead of above-mentioned $\triangle I$, are chosen and in addition, if a great numder of the storms are chosen, the effect of the daily variation will be diminished more effectively. The diagram plotted on the ground of the view-point is Fig. 3.

Comparing Fig.3 with Figs.1–2, it is found that on the whole there is a strong resemblance between them even though there are some differences among corresponding points respectively. The very strong resemblance is how $\triangle I/\triangle H$ depends upon T_m. As for Figs. 4–5 this also is all the same. Consequently it may be concluded that the dependency of $\triangle I/\triangle H$ on T_m is not due to the familiar daily variation of the cosmic-ray inensity.

Figs. 4–5 also are the diagrams plotted by reason of an anxiety as follows : the anxiety that the result obtained from the statistical treament of the data of only one observatory (Tokyo) may be the only insignificant one. As indicated in Table 2, both Huancayo and Cheltenham differ largely in longitude and considerably also in latitude from Tokyo. Nevertheless the tendency that Figs. 4–5 indicate is greatly similar to the one that Figs. 1–3 indicate. In other words, even in the cases that the data of both observatories (Huancayo and Cheltenham) are used, how $\triangle I/\triangle H$ depends upon T_m is all the same as the previous cases.

From this result it is evident that the dependency of $\triangle I/\triangle H$ on T_m is not an insignificant local phenomenon

Moreover, on the ground of other ideas I seeked for correlations between $\triangle H$ and $\triangle I$, like the above, by the medium of the following times :

(1) The times (T_h) when the horizontal intensities of the earth's field attain to the minimum values (cf. Table 3)

(2) The times (T_i) when the cosmic-ray intensities attain to the minimum values (cf. Table 3).

(3) The times (T_c) when the magnetic storms commence. (cf. Table 3).

But, any correlations between them could not find (cf. Figs. 6–8). One of these figures, Fig. 8, seems to be indicating a faint correlation between abscissas and ordinates. However, comparing with Figs. 1–3, the correlation between them is much faint.

Of course, I could not find any direct correlations between $\triangle I$ (adopted as the ordinates) and $\triangle H$ (adopted as the abscissas) like the reports by many investigators (cf. Fig. 9).

These above results (which Figs. 6–9 indicate) also may be of help to confirm that the dependency of $\triangle I/\triangle H$ on T_m is not due to the familiar daily variation of the cosmic-ray intensity

Table 3 — Cosmic-radiation disturbances and associated magnetic storms, 1949—1952.

No.	Magnetic storms(1)							Cosmic-radiation disturbances(3)			$\triangle I/\triangle H$
	Commenced		Beginning of main phase		Max. decrease(2) of hori. comp. (H)		Range of H	Cosmic-ray intensity			
								Max. decrease		Decrement	$\times 10^3$
	Date	JCST (T_c)	Date	JCST (T_m)	Date	JCST (T_h)	($\triangle H$)	Date	JCST (T_i)	($\triangle I$)	
	1949	h m		h m		h m	γ	1949	h m	%	%/γ
1	Jan. 25	03 27		08 50		11 00	407	Jan. 25	22 00	− 5. 0	−12. 3
2	26	01 45		40 03		10 00	298	28	02 00	− 2. 0	− 6. 7
3	Dec. 30	15 00	Dec. 31	40 00		20 00	73	Jan. 1	10 00	− 1. 4	−19. 2
	1950							1950			
4	Jan. 2	01 44		90 00		12 00	31	Jan. 2	19 00	− 1. 2	−38. 7
5	Feb. 2	11 00		15 20		21 00	102	Feb. 4	04 00	− 0. 8	− 7. 8
6	20	08 39	Feb. 21	02 40		09 00	222	21	20 00	− 0. 7	− 3. 2
7	Mar. 14	09 30		16 00	Mar. 15	12 00	85	Mar. 16	00 00	− 1. 6	−18. 8
8	Apr. 12	13 18		13 20		21 00	74	Apr. 14	21 00	− 1. 8	−24. 3
9	June 6	09 16		11 00		19 00	50	June 6	15 00	− 3. 0	−60. 0*
10	16	23 33	June 17	14 00		19 00	52	17	20 00	− 0. 9	−17. 3
11	29	17 23		22 00	June 30	13 00	168	Jul. 1	23 00	− 0. 8	− 4. 8
12	Jul. 3	17 42	Jul. 4	05 00		11 00	104	6	15 00	− 0. 5	− 4. 8
13	Aug. 7	19 54	Aug. 8	06 00		23 00	254	Aug. 8	23 00	− 0. 6	− 2. 4
14	19	19 06		19 10	Aug. 20	17 00	317	21	22 00	− 1. 0	− 3. 2
15	Sep. 16	19 18		21 00	Sep. 18	10 00	107	Sep. 18	05 00	− 0. 6	− 5. 6
16	23	18 22		18 50		21 00	90	24	10 00	− 0. 3	− 3. 3
17	Oct. 14	11 00		16 00		22 00	105	Oct. 17	00 00	− 0. 8	− 7. 6
18	27	10 00		11 00		20 00	180	31	09 00	− 2. 7	−15. 0
19	Nov. 4	09 30		13 00		21 00	131	Nov. 5	15 00	− 0. 7	− 5. 3
20	10	08 30		13 00		20 00	148	11	20 00	− 1. 2	− 8. 1
21	Dec. 5	14 00	Dec. 6	09 40		19 00	111	Dec. 9	06 00	− 3. 0	−27. 1
22	22	15 00		19 50		23 00	116	24	08 00	− 0. 9	− 7. 8
	1951							1951			
23	Jan. 26	12 30	Jan. 27	02 00		04 00	64	Jan. 27	12 00	− 1. 3	−20. 3
24	Mar. 7	16 15		19 00		22 00	120	Mar. 9	02 00	− 1. 7	−14. 2
25	16	19 04	Mar. 17	15 00		19 00	80	17	22 00	− 1. 6	−20. 0
26	22	06 00		18 30		22 00	90	25	01 00	− 0. 9	−10. 0
27	May 9	15 20		15 40	May 10	18 00	108	May 13	02 00	− 1. 4	−13. 0
28	23	12 00		16 00	May 24	11 00	81	25	03 00	− 2. 3	−28. 4
29	25	03 46		06 00	27	10 00	113	26	21 00	− 1. 0	− 8. 9
30	June 5	10 40	June 6	15 10		17 00	83	June 8	13 00	− 0. 7	− 8. 4
31	12	04 10		15 00		20 00	84	14	07 00	− 0. 8	− 9. 5
32	15	02 51		07 00		17 00	62	15	20 00	− 1. 4	−22. 6
33	18	02 02		06 40		16 00	148	20	00 00	− 1. 2	− 8. 1
34	Jul. 2	07 26		07 30		16 00	168	Jul. 3	08 00	− 1. 0	− 5. 9
35	22	12 30		13 00		18 00	78	23	18 00	− 1. 3	−16. 7
36	28	10 07		11 30		17 00	64	30	13 00	− 1. 1	−17. 2
37	Aug. 13	12 01		13 00	Aug. 14	00 00	70	Aug. 14	19 00	− 1. 6	−22. 8
38	16	16 48		17 00		19 00	100	17	15 00	− 1. 8	−18. 0
39	Sep. 27	09 05		11 30		21 00	112	Sep. 29	07 00	− 1. 0	− 8. 9
40	Oct. 7	18 00	Oct. 8	10 00		17 00	138	Oct. 9	04 00	− 1. 8	−13. 0
41	Nov. 13	16 00		17 00		19 00	93	Nov. 14	18 00	− 1. 5	−16. 1
42	Dec. 28	06 36		12 00		17 00	240	Dec. 29	03 00	− 1. 5	− 6. 3
43	31	01 24		12 00		20 00	90	Jan. 1	01 00	− 1. 3	−14. 4
	1952							1952			
44	Jan. 5	06 08		09 00		18 00	114	Jan. 6	16 00	− 1. 0	− 8. 8
45	27	15 00		17 00		23 00	102	29	03 00	− 2. 0	−19. 6
46	Feb. 24	06 25		07 45		19 00	186	Feb. 26	10 00	− 1. 0	− 5. 4
47	Mar. 3	16 30		21 00	Mar. 4	20 00	182	Mar. 4	18 00	− 0. 3	− 1. 6
48	Apr. 21	20 51		22 00	Apr. 22	00 00	187	Apr. 22	19 00	− 1. 0	− 5. 4
49	May 7	11 00		12 30		18 00	101	May 7	16 00	− 1. 0	− 9. 9
50	18	04 00		07 00		20 00	102	19	12 00	− 1. 2	−11. 8
51	June 8	12 00		16 00		19 00	69	June 9	21 00	− 2. 5	−36. 2
52	14	12 00		16 30		22 00	80	15	19 00	− 1. 3	−16. 3
53	22	16 00	June 23	03 00	June 24	12 00	111	23	16 00	− 1. 9	−17. 1
54	30	04 32		10 00		17 00	225	Jul. 2	00 00	− 1. 2	− 5. 3
55	Jul. 2	05 33		08 30		19 00	55	2	16 00	− 0. 6	−10. 9
56	Aug. 17	10 20		16 00		21 00	108	Aug. 19	18 00	− 1. 7	−15. 7
57	29	23 04	Aug. 30	07 00		13 00	101	31	16 00	− 0. 7	− 6. 9
58	Sep. 1	06 06		12 00		18 00	92	Sep. 2	16 00	− 0. 6	− 6. 5
59	29	00 25		13 30		20 00	111	29	19 00	− 1. 0	− 9. 0
60	Oct. 21	19 09		19 30	Oct. 22	04 00	73	Oct. 23	14 00	− 1. 2	−16. 4

Dates in blanks are the same ones as in previous row.

(1) : Quotated intactly from the printed geomagnetic data of Kakioka Magnetic Observatory with exception of (2).

(2) : Evaluated from diagrams plotted by using the printed geomagnetic data of Kakioka Magnetic Observatory.

(3) : Evaluated from diagrams plotted by using the printed cosmic-ray intensity data of Scientific Research Institute, Tokyo.

* : Excluded from Fig. 1 on account of extraordinary great value.

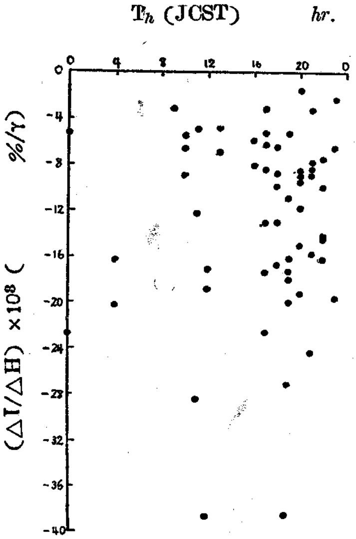

Fig. 6. Relation diagram between △I and △H by the medium of T_h due to the data at Tokyo.

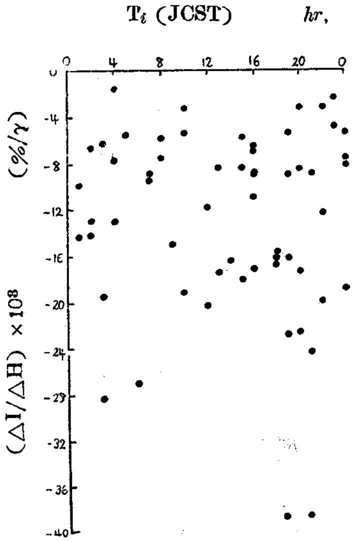

Fig. 7. Relation diagram △I and △H by the medium of T_i due to the data at Tokyo.

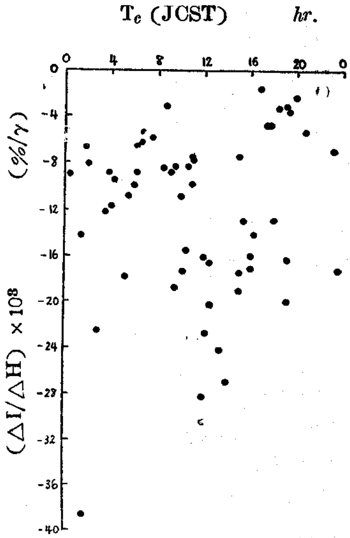

Fig. 8. Relation diagram between △I and △H by the medium of onset-times (T_e) of magnetic storms due to the data at Tokyo.

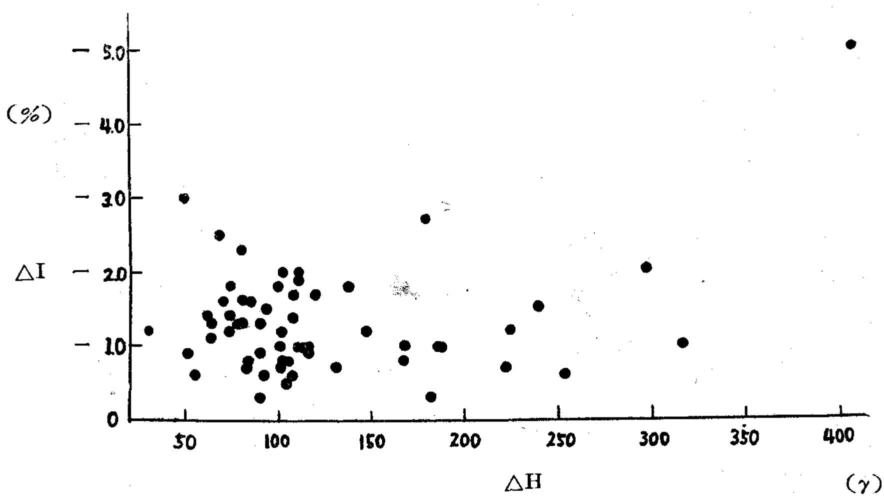

Fig. 9. Direct relation diagram between △I and △H due to the data at Tokyo.

5. Conclusions

From the above we may conclude as follows :

(1) $\triangle I/\triangle H$ depends upon T_m (is indicated by local time) and changes with one day period.

(2) $\triangle I/\triangle H$ attains to the minimum value (the maximum value as for the absolute value) during two or four hours after the noon.

In other words about these, between the decrements of the cosmic-ray intensity and the changes in the horizontal intensity of the earth's field at the time of the magnetic storms there exists an evident correlation by the medium of the onset-time (local time) of the main phase of the magnetic storms.

And as for the magnetic storms which the main phase commences during the day time, the decreases of the cosmic-ray intensity associated with the storms are great in comparison with the changes in the earth's field and as for the magnetic storms which the main phases commence during the night-time, those are contrary.

When the main phases of the referred storms commence during two or four hours after the noon, the decreases of the cosmic-ray intensity in comparison with the changes in the horizontal intensity of the earth's field are the greatest.

(3) There are no correlations like the above by the medium of the following times:

(i) The times when the horizontal intensities of the earth's field attain to the minimum values (cf. Table 3)

(ii) The times when the cosmic-ray intensities attain to the minimum values (cf. Table 3)

(iii) The times when the magnetic storms commence. (cf. Table 3).

(4) There are no direct correlations between the changes in the horizontal intensity of the earth's field (abscissas) and the decrements of the cosmic-ray intensity (ordinates). (cf. Fig. 9).

Table 4 – Cosmic-ray intensity variations and magnetic storms at Tokyo, 1948-52.

No.	Magnetic storms(1)			Cosmic-ray intensity	$\triangle I/\triangle H \times 10^3$
	Storm-time	Begin. of main phase	Range of H	Decrement(2)	
	Date	JCST (T_m)	($\triangle H$)	($\triangle I$)	
	1948	h m	γ	%	%/γ
1	Dec. 14–17	10 00	87	−0.97	−11.1
2	21–	15 00	90	−0.62	−6.9
3	24–26	12 00	86	−0.97	−11.3
4	Dec. 30–Jan. 3	23 00	108	−1.53	−14.2
	1949				
5	Jan. 25–	08 25	407	−1.61	−4.0
6	Apr. 13–17	06 00	91	−2.09	−23.0
7	30	03 00	48	−0.46	−9.6
8	May 4–5	06 51	100	−0.68	−6.8
9	Nov. 29–Dec. 1	08 30	111	−0.50	−4.5

Table 4—Continued.

No.	Magnetic stroms(1)				Cosmic-ray intensity	△I/△H×10³
	storm-time		Begin. of main phase	Range of H	Decrement(2)	
	Date		JCST (Tm)	(△H)	(△I)	
	1950		h m	γ	%	%/γ
10	Jan.	19−23	18 00	95	−1. 17	−12. 3
11	Feb.	23−26	20 40	133	−2. 43	−18. 3
12	Mar.	6− 8	17 00	104	−0. 88	−8. 5
13	Apr.	22−26	14 00	129	−2. 03	−15. 7
14	June	6− 7	11 00	50	−0. 43	−8. 6
15		24−26	16 30	108	−1. 67	−15. 5
16	June	29−Jul.3	22 00	168	−0. 57	−3. 4
17	Jul.	3− 9	05 00	104	−0. 28	−2. 7
18		24−26	14 00	166	−0. 21	−1. 3
19	Aug.	19−22	19 10	317	−1. 28	−4. 4
20	Sep.	16−21	21 00	107	−0. 40	−3. 7
21		23−27	18 50	90	−1. 63	−18. 1
22	Oct.	14−16	16 00	105	−0. 28	−2. 7
23	Oct.	27−Nov.3	11 00	180	−1. 42	−7. 9
24	Nov.	10−14	13 00	148	−0. 55	−3. 7
25	Dec.	5−11	09 40	111	−1. 15	−10. 4
26		12−17	17 18	150	−1. 18	−7. 9
27		22−31	19 50	116	−0. 65	−5. 6
	1951					
28	Jan.	26−29	02 00	64	−0. 55	−8. 6
29	Mar.	7−16	19 00	120	−1. 60	−13. 3
30		16−20	15 00	80	−1. 33	−16. 6
31	May	9−13	15 40	108	−1. 37	−12. 7
32		23−26	16 00	81	−1. 85	−22. 8
33	June	12−14	15 00	84	−1. 19	−14. 2
34		15−17	07 00	62	−1. 95	−31. 4
35	July	22−24	13 00	78	−0. 89	−11. 4
36		28−30	11 30	64	−0. 98	−15. 3
37	Sep.	19−25	23 30	175	−0. 77	−4. 4
38	Oct.	7−12	10 00	138	−1. 28	−9. 3
39		28−31	21 00	253	−0. 90	−3. 6
40	Nov.	13−16	17 00	93	−0. 48	−5. 2
	1952					
41	Dec.	31−Jan.2	12 00	90	−0. 50	−5. 6
42	Jan.	5− 9	09 00	114	−0. 70	−6. 1
43		27−31	17 00	102	−1. 33	−13. 0
44	Feb.	24−25	07 45	186	−1. 14	−6. 1
45	Mar.	3− 7	21 00	182	−1. 47	−8. 1
46	Apr.	21−24	22 00	187	−0. 22	−1. 2
47	Apr.	28−May6	11 00	135	−1. 54	−11. 4
48	May	18−20	07 00	102	−0. 85	−8. 3
49	June	8−13	16 00	69	−1. 06	−15. 4
50		22−25	03 00	111	−0. 88	−7. 9
51	July	2− 3	08 30	55	−0. 45	−8. 2
52	July	31−Aug.1	15 00	79	−1. 07	−13. 5
53	Aug.	17−20	16 00	108	−1. 16	−10. 8
54		29−31	07 00	101	−0. 43	−4. 1
55	Oct.	3− 7	06 30	124	−0. 86	−6. 9
56		21−22	19 30	73	−0. 77	−10. 5

(1) : Excerpted from the printed geomagntic data of Kakioka Magnetic Observatory.

(2) : Evaluated by use of daily mean in the printed data of Scientific Research Institute, Tokyo.

Table 5—Cosmic-ray intensity variations and associated magnetic stroms at Huancayo, 1941—46, and 1950.

No.	Magnetic storms(1): Storm—time, Greenwich Date	Magnetic storms(1): Beginning* of main phase, GMT	Magnetic storms(1): Beginning* of main phase, Local** time (T_m)	Magnetic storms(1): Range of H (ΔH)	Cosmic-ray intensity: Decrement(2) (ΔI)	$\Delta I/\Delta H \times 10^3$
	1941	h	h	γ	%	%/γ
1	Apr. 18	18	13	61	−0.6	−9.8
2	19	12	7	58	−0.3	−5.2
3	24−26	9	4	180	−0.2	−1.1
4	May 4	4	23	78	−0.1	−1.3
5	June 9	10	5	61	−1.4	−2.3
6	20−21	4	23	45	−0.5	−1.1
7	Sep. 18−20	15	10	626	−1.9	−3.0
8	Nov. 27−28	16	11	300	−0.4	−1.3
9	Dec. 1	9	4	530	−0.9	−1.7
	1942					
10	Feb. 28−Mar. 1	15	12	470	−3.7	−7.9
11	Mar. 26	13	8	380	−0.5	−1.3
12	Oct. 28−31	13	8	385	−0.4	−1.0
	1943					
13	Jan. 4	12	7	150	−0.1	−0.7
14	17	13	8	220	−0.2	−0.9
15	Aug. 28−31	10	5	251	−0.6	−2.4
16	Nov. 19−27	12	7	225	−0.6	−2.7
	1944					
17	Feb. 7	13	8	180	−0.3	−1.7
18	Mar. 26−27	13	8	112	−1.4	−12.5
19	Dec. 13	15	10	305	−0.8	−2.6
	1945					
20	Jan. 15	12	7	307	−0.1	−0.3
21	Mar. 11	12	7	182	−0.9	−4.9
22	12	10	5	211	−0.3	−1.4
23	15	14	9	354	−1.4	−4.0
24	Apr. 11	12	7	196	−0.2	−1.0
25	Oct. 12	12	7	218	−0.4	−1.8
26	24	12	7	517	−0.1	−0.2
	1946					
27	Jan. 3	10	5	463	−0.6	−1.3
28	Feb. 7−8	11	6	702	−2.7	−3.8
29	Mar. 10	12	7	297	−1.5	−5.1
30	22−25	0	19	380	−0.9	−2.4
31	28	7	2	1033	−2.2	−2.1
32	Jul. 26−27	21	16	480	−7.4	−15.4
33	Sep. 17−20	0	19	272	−2.5	−9.2
34	21−23	3	22	848	−1.9	−2.2
35	Nov. 24	13	8	785	−1.1	−1.4
	1950					
36	Sep 30−Oct. 6	2	21	314	0.0	0.0
37	Oct. 16−17	8	3	295	0.0	0.0
38	Oct. 28−Nov. 1	3	22	577	−0.4	−0.7
39	Nov. 10−12	8	3	207	0.0	0.0
40	24−30	0	19	250	−0.4	−1.6
41	Dec. 22−27	0	19	282	−1.2	−4.3

(1) : Excerpted from "Principal Magnetic Storms" tables in the "Terrestrial Magnetism and Atmospheric Electricity".
* : Presumed from tables "Three-Hour-Range Indices" in above magazine.
** : 75° West Meridian Mean Time.
(2) : Evaluated by use of daily mean in references (13) and (14).

Table 6-Cosmic-ray intensity variations and associated magnetic stroms at Cheltenham, 1940-42,1946, and 1950-51.

No.	Magnetic storms(1)					Cosmic-ray intensity	△I/△H×10³
	Storm-time		Beginning* of main phase		Range of H	Decrement(2)	
	Greenwich Date		GMT	Local** time(Tm)	(△H)	(△I)	
		1940	h	h	γ	%	%/γ
1	Oct.	1	3	22	122	−0.4	−3.3
2		7−8	18	13	118	−0.7	−5.9
3	Nov.	12−13	8	3	188	−1.2	−6.4
4	Dec.	20−23	9	4	134	−0.2	−1.5
		1941					
5	Mar.	1−7	6	1	1367	−2.6	−1.9
6		13−17	0	19	130	−0.4	−3.1
7		28−31	10	5	135	−0.8	−5.9
8	Apr.	18−20	2	21	96	−0.4	−4.2
9		24−26	10	5	150	−0.6	−4.0
10	June	13−14	4	23	142	−0.6	−4.2
11	July	4−7	3	22	1466	−0.6	−0.4
12	Aug.	4−5	2	21	308	−1.0	−3.2
13		25−30	22	17	132	−1.1	−8.3
14	Sep.	13−16	12	7	144	−1.2	−8.3
15		18−21	10	5	2540	−1.5	−5.9
16	Oct.	31−Nov.1	15	10	260	−0.7	−2.7
17	Dec.	1−2	9	4	230	−0.6	−2.6
		1942					
18	Feb.	23−24	0	19	110	−1.9	−17.3
19	Mar.	1−2	8	3	455	−6.4	−14.1
		1946					
20	Mar.	23−29	0	19	2160	−2.9	−1.3
21	July	26−27	1	20	1500	−7.2	−4.8
22	Sep.	17−19	2	21	320	−2.5	−7.8
23		21−24	4	23	1150	−1.7	−1.5
		1950					
24	Oct.	16−18	7	2	76	−0.2	−2.6
25	Oct.	28−Nov.1	9	4	107	−0.6	−5.6
26	Nov.	3−4	2	21	118	−0.1	−0.9
27		22−23	15	10	76	−0.5	−6.6
		1951					
28	Feb.	27−Mar.1	0	19	214	−0.7	−3.3
29	Mar.	7−10	12	7	92	−0.3	−3.3
30		22−24	12	7	125	−0.4	−3.2
31	Apr.	2−11	16	11	76	−1.0	−13.2
32		18−19	8	3	145	−0.4	−2.8
33		20−23	21	16	107	−0.9	−8.4
34		24−26	17	12	94	−1.3	−13.8
35	May	1−5	16	11	79	−0.6	−7.6
36		9−10	3	22	170	−0.9	−5.3
37	June	14−16	19	14	173	−1.9	−11.0
38		17−18	21	16	135	−0.4	−3.0
39		18−19	3	22	137	−1.0	−7.3
40	July	1−5	0	19	248	−0.4	−1.6
41		22−23	22	17	80	−0.8	−10.0
42	July	31−Aug.3	15	10	74	−0.7	−9.5
43	Aug.	20−22	21	16	87	−0.6	−6.9
44	Sep.	11−14	19	14	91	−1.1	−12.1
45		27−28	1	20	118	−0.1	−0.9
46	Oct.	7−11	18	13	86	−1.0	−11.6
47		13−14	22	17	85	−0.2	−2.4
48		17−20	15	10	163	−0.2	−1.2
49		28	12	7	370	−0.6	−1.6

(1) : Excerpted from tables, "Principal Storms" in the "Terrestrial Magnetism and Atmospheric Electricity".
* : Presumed from tables "Three-Hour-Range Indices" in above magazine.
** : 75° West Meridian Mean Time
(2) : Evaluated by use of daily mean in references (13) and (14).

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