Note on the Average Lunar Diurnal Variation at Kakioka

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概　要

柿岡に於ける地磁気太陰日変化の季節変化，及び黒点との相関に，他の観測所の結果と稍々異る点が見出されることを，主として地磁気偏角の結果から述べる．

§ 1. Introduction

The lunar diurnal variation of the magnetic field has been studied by many authors, and its main characteristics are well known. Moreover, the process is explained by the so-called dynamo theory. But, a few features remain unexplained. It has been already indicated that Sq and L current systems undergo large seasonal changes, more intensively in summer than in equinox. But, while the ratio of summer to equinox for the L current system is 2.6, that for the Sq current system is only about half as much. Both Sq and L current system increases from sunspot minimum to sunspot maximum of the solar cycle. But, contrary to what may be expected from the nature of the seasonal variations, the increase of Sq is greater than the increase of L. Thus, while Sq increase by about 50 %, L increase by only about 20 % [1]. This paper is notes from the such view point, on the average lunar diurnal variation at Kakioka, briefly described in the previous paper [2].

§ 2. Statistical Results and discussions

In the previous paper [2], the average lunar diurnal variation of the declination at Kakioka is calculated, based on 21 years' observation. The statistical treatment are also described in it. The result, relating to the subject of this paper are reproduced in Table 1. At first sight of the table, the ratio summer/winter of C_2 become larger from sunspot minimum to sunspot maximum. In order to compare with Sq, the first and second harmonics of Sq at Kakioka are tabulated in Table 2. [3]. In this case, the ratios, summer/winter of both harmonics decrease from sunspot minimum to sunspot maximum. Although the increasing or decreasing is rather small in quantity and the features are not much distinguished, the ratios of the mean of all years (ignoring the sunspot mumber) are 1.6 for L and 3 or 4

Table 1. The second harmonics of the average lunar diurnal variation of declination, for sunspots max., intermediate and min. years. Unit C_2 : minute ; φ_2 : degree

		Summer	Equinox	Winter	Year
Sunspot max.	C_2	0.28	0.14	0.14	0.14
	φ_2	95	98	200	118
Sunspot inter.	C_2	0.27	0.13	0.13	0.12
	φ_2	86	101	199	110
Sunspot min.	C_2	0.19	0.11	0.13	0.09
	φ_2	94	102	197	124
All years	C_2	0.24	0.12	0.14	0.11
	φ_2	100	99	199	114

Table 2. The first and second harmonics of the solar diurnal variation on calm days of declination. Unit C_1, C_2 : minute

		Summer	Equinox	Winter	Year
Sunspot max.	C_1	1.87	1.34	0.53	1.26
	C_2	1.99	1.29	0.75	1.33
Sunspot min.	C_1	1.60	1.00	0.28	1.00
	C_2	1.46	0.97	0.52	0.97
All years	C_1	1.77	1.17	0.42	1.12
	C_2	1.68	1.12	0.59	1.12

for Sq. That is, the seasonal variation of amplitudes of L are less than that of Sq. Furthermore, the increasing of C_2 of L from sunspot minimum to sunspot maximum is distinguished in summer, about 50 %, but much less in other seasons. Concerning Sq, the tendency cannot be detected. And the increases of the second harmonics from sunspot minimum period to sunspot maximum period are about same. While the increase of the first harmonics of Sq are different for each season and that for declination is rather small, as compared with the increase of C_2 for L. Furthermore, the year to year change of C_2 of L are highly correlated to that of annual means of sunspot numbers than the first or second harmonics of Sq does. These features may be different from the result at other observatories. And also, we may be able to say that the second harmonics for equinoxial inequality is rather small than that for winter. The tendency will be also shown in Table 3 and 4, which gives the second harmonics of L of horizontal and vertical components at Kakioka. The values in the tables are reduced from three years' observational data (1937–1939) by the same method as that, of declination.

Table 3. The second harmonics of the average lunar diurnal variation of horizontal component for 1937~1939.

Unit C_2 : gamma, φ_2 : degree

	Summer	Equinox	Winter	Year
C_2	1.05	0.87	0.90	1.00
φ_2	98	103	199	124

Table 4. The second harmonics of the average lunar diurnal variation of vertical component for 1937~1939.

Unit C_2 : gamma, φ_2 : degree

	Summer	Equinox	Winter	Year
C_2	1.85	0.65	0.78	1.20
φ_2	105	109	203	126

The average lunar diurnal variation reduced from only three years' observation by the method may de affected by large accidental errors. In order to obtain a well determined lunar diurnal variation, it is necessary to combine the inequalities for many months. The remained irregular variation are more or less candidly shown in the inequalities, given in Fig. 3 and 4, in comparison with ones in Fig. 2. But, the main features such as the seasonal changes may

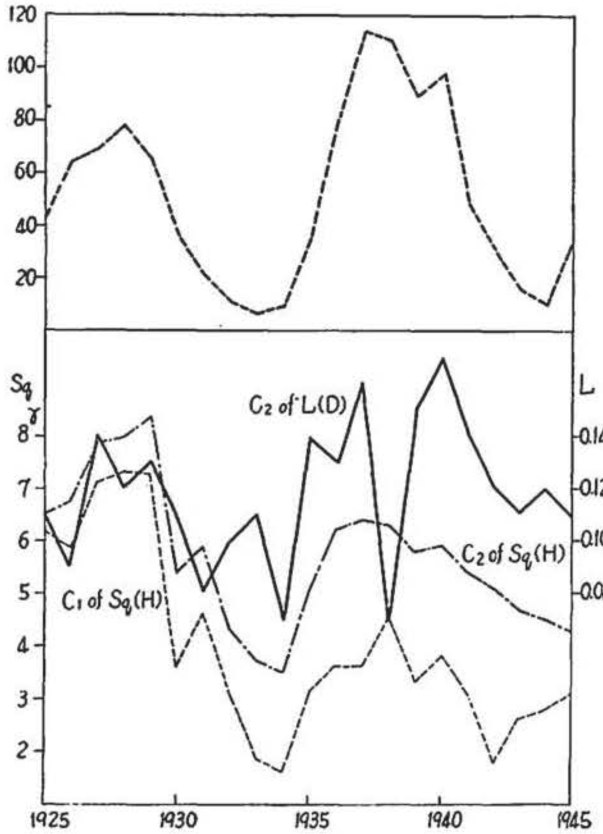

Fig. 1. The year to year changes of the annual mean of the sunspot number, the amplitude of the first and secomd harmonics of *Sq* (after Y. Yokouchi) and the second harmonics of *L*, 1925~1945.

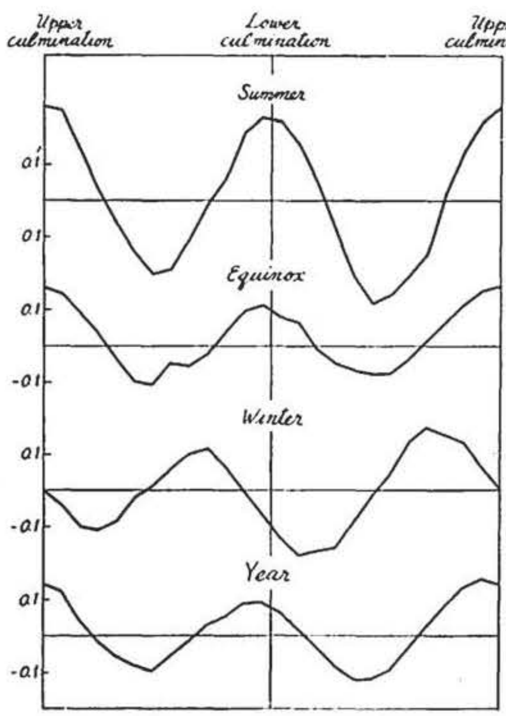

Fig. 2. The average lunar diurnal variation of west magnetic declination for each season and year, 1925~1945.

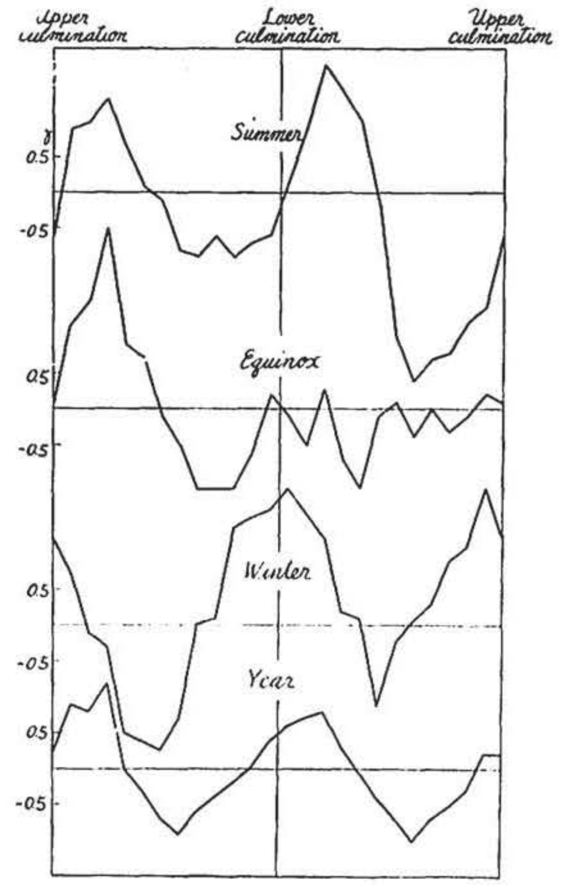

Fig. 3. The average lunar diurnal variation of horizontal component for each season and year, 1937~1939.

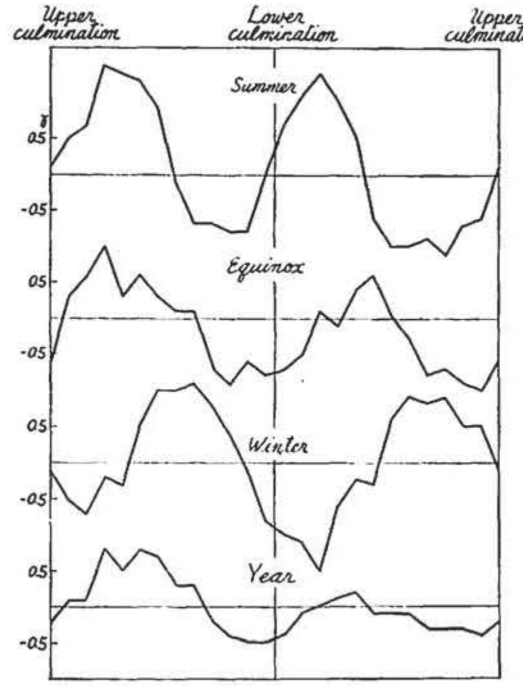

Fig. 4. The average lunar diurnal variation of vertical component for each season and year, 1937~1939.

be appeared, though indefenitely. Respecting *Sq* at Kakioka, both of the first and second harmonics for equinox are greater than those for winter and smaller than those for summer, respectively. Otherwise, the C_2 of L also at other observatories has no such behaviour. Theoretically, the magnetic lunar variation depends on linearly the integrated conductivity and the lunar tidal air motion in the ionosphere.

The lunar atmospheric tide in the ionosphere may be more or less different from that on the ground. But, the above mentioned feature is well shown in the Table 5 and 6. The values show the same order of the amplitude for equinox and for winter. On the other hand, although we cannot indicate decidedly the layer in which the current mainly flows, the seasonal variation of the conductivity of the F-layer and also, of the E-layer are not favorable to that of L. The seasonal change of the conductivity of the F-layer are such that have the maximum values

Table 5. The lunar diurnal variation of the real height of maximum ionization in Region F at Kokubunji, from Jan. 1947 to Feb. 1948. Unit C_2 : Km ; φ_2 : degree (after S. Matsushita)

	June Solstice	Equinox	Dec. Solstice	Mean
C_2	3.5	3.2	3.1	3.0
φ_2	272	272	223	252

Table 6. The lunar atmospheric tide near the ground at about 35°N. Unit C_2 μb ; φ_2 : degree (after S. Chapman)

	June Solstice	Equinox	Dec. Solstice	Mean
C_2	31	24	24	25
φ_2	79	82	39	65

in equinox. That of the E-layer are proportional to cos χ or $(\cos \chi)^{\frac{1}{2}}$. Therefore, the minimum values are in winter, on the average. Even if, taking into the other layers, the total conductivity in equinox, may be larger than in winter.

Thus the equinoxial inferiority of C_2 may be in some degree incomprehensible. Hence, the tabulated results may be attributed to the statistical treatment, by some possibility, with a weak point that the adopted data include all lunar sequences for the period, except missing records, ignoring the magnetic activity. But, the equinoxial maximum of the magnetic activity is statistically admitted ever since. This holds good with the observations at Kakioka as well. From the parallelism between the solar activity, the magnetic activity and the increase of L with the solar activity, C_2 must be overestimated.

Secondary, the S are subtracted at the outset in the form of the monthly mean solar daily variation S. From the day-to-day changes of the solar diurnal variation, the treatment results in that S may be not fully eliminated in the lunar diurnal inequalities. If a very large amount of material were available, the rearrangement of the hourly differences according to lunar time, and the subsequent summation, should cause the residual S to be averaged out ; but there is a possibility that this was not achieved in some reductions.

Acknowledgement

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References

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