A RELATION BETWEEN THE SHORT TIME VARIATIONS OF COSMIC RAYS AND GEOMAGNETIC FIELD CHANGE

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ABSTRACT

First, we report an event of ~37min. periodicity in cosmic ray intensity observed at Akeno(38°47'N, 138°30'E, 900m above s.l., cutoff 10.4 GV) during 1300~1900 UT on April 25th, 1984, just a day before Forbush decrease of April 26th. This event seemed to be followed by the periodic variations of the geomagnetic field observed at Kakioka(36°23'N, 140°18'E). The regression coefficient between them was obtained ~-0.07%/10nT.

Second, we show that in general the power spectral density of cosmic rays in the frequency of 10^{-4}~10^{-3}Hz correlates positively with the fluctuations of geomagnetic field(Dst field) around ~1.2×10^{-4}Hz. From the analysis of 47 days data(April 14th to June 13th, 1984), the regression curve was obtained as $y=0.275x^{0.343}$ with the correlation coefficient of 0.48, where x and y mean Fourer components of Dst field summed over 1.04 ~1.39×10^{-4}Hz and cosmic ray power spectral density averaged over 10^{-4}~10^{-3}Hz respectively.

1.Introduction. Dhanju and Sarabhai(1967, 1969) first discussed the cosmic ray power spectrum. They showed that the general frequency dependence of the power spectra in the frequency range of 10^{-6}~10^{-3}Hz and also several periodicity in 1.67~8 $\times10^{-3}$Hz. But Fujii et al(1975) argued against their result obtained in 10^{-4}~10^{-3}Hz. Theoretically, Owens and Jokipii(1972,1974), Toptygin and Vasilijev(1977) discussed the power spectra in the relation to the random magnetic field in the interplanetary space or in the magnetosheath. However, the validity of their model are limitted to the frequency range less than~10^{-5}Hz.

On the other hand, the existence of short time variations of cosmic rays(10^{-4}~10^{-3}Hz) are reported by several authors by the exhibition of the enhancement in the power spectra after subtracting the poisson noise level or clear vissible oscillations in cosmic ray counting rates(Slade,1972; Kodama et al.,1975; Kozlov et al., 1975; Attolini et al.,1979; Debrunner et al., 1983). However, no clear relation to some other interplanetary or geomagnetic field parameters(e.g., Kp, Dst etc.) has been found.

In this paper, at first, we briefly report the periodic variations of cosmic ray intensity of ~37min. period observed on April 25th, 1984, which seems anticorrelated well to the geomagnetic field change observed at Kakioka(Sakai et al., 1985).

The above event may suggest that the cosmic ray power spectral density around 10^{-4}~10^{-3}Hz are affected by the fluctuations of geomagnetic field, especially Dst field around the same frequency. Thus, we analysed both data of 47days and found that the level of cosmic ray power spectral density in the frequency range of 10^{-4}~10^{-3}Hz are related to the Dst field around 10^{-4}Hz with the correlation coefficient of 0.48.

<u>2. Results.</u> We show 3 minute data of cosmic rays, together with the H-component of the geomagnetic field observed at Kakioka from the time of 1200 to 1900 UT on April 25th in Fig.1. In the figure, errors of the cosmic ray are derived from counting rates.

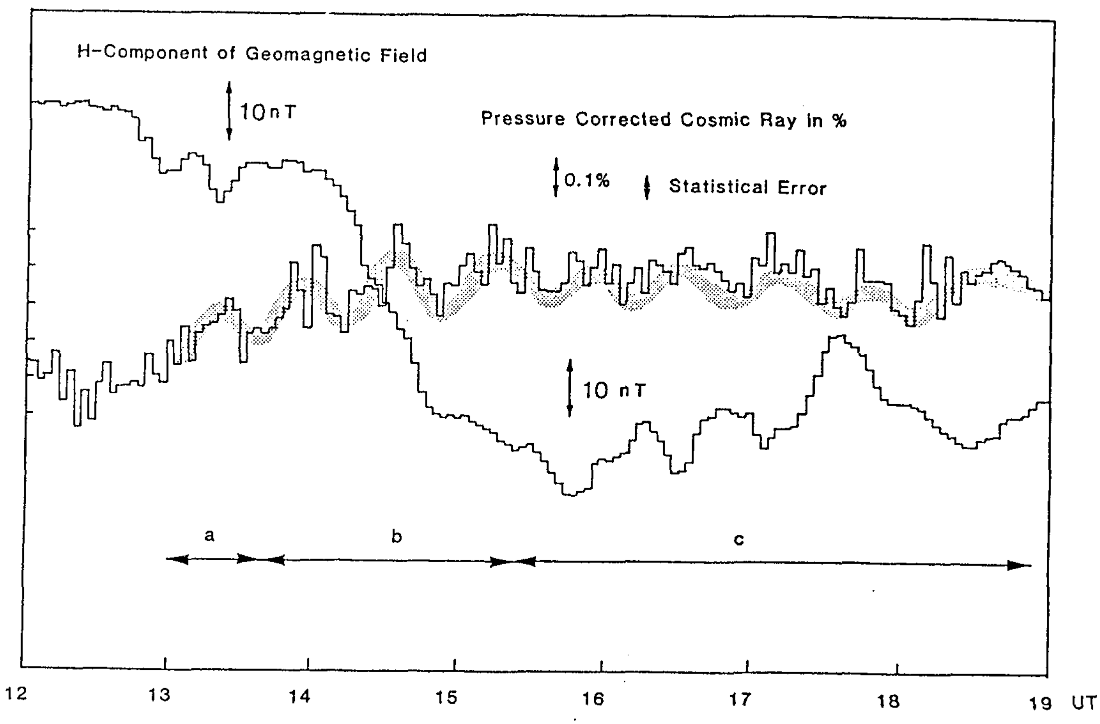

Figure 1. The cosmic ray data of 3 minute value are plotted together with the H-component of the geomanetic field observed at Kakioka from the time period of 1200 UT to 1900 UT on April 25th. The clear oscillations of the cosmic ray counting rates (dotted screen) are seen in anti-correlation with the H-component.

It is clear from the figure that, as shown by a wavy dotted screen, the counting rate of cosmic rays oscillates in anti-correlation with the change of the H-component, especially in the intervals indicated with a letter a and c in the figure. During the time of 1600 ~1700 UT, the oscillating part of the geomagnetic field has an amplitude of ~10nT in p-p(peak-to-peak). At the same time, the counting rates of cosmic rays change ~0.07% in p-p, almost out of phase with the change of the H-component.

From this, we can estimate changing ratio (hereafter refferd to as geomagnetic coefficient) of cosmic rays to the H-component at -0.07%/10nT. More detail discussion are seen in Ref.10.

Also, we can estimate a value of the geomagnetic coefficient following Obayashi(1961) by supposing that the cosmic ray counting rates may be changed by the change of cut off rigidities due to Dst field. The obtained geomagnetic coefficient was ~0.3%/10nT. This may be consistent with the observed value if we consider that we don't know about Dst field shorter than 1-hour data. Thus, it seems reasonable that the observed oscillations in cosmic ray counting rates with the period of ~37 min. are mainly due to the change of geomagnetic field.

Further, if we suppose that the above good relationship between cosmic ray intensity and geomagnetic field (probably Dst field) in the frequency range of 10^{-4}~10^{-3}Hz in general exist for not only special days, but also all days, we come to an idea that the power spectral density in the frequency of 10^{-4}~10^{-3}Hz may closely related to the fluctuation of Dst field around the same frequency range. We analysed the data of 47 days through April 14th to June 13th, 1984. The power spectral density of cosmic rays are calculated by using 1-min. data on each day. On the other hand, the data of Dst field, which is available for us, are unfortunately 1-hour data only. 24 data points for a day are too short to get a significant power spectral density around ~10^{-4}Hz. Hence we Fourier analysed 1-day Dst field after running average of 5 hours. and computed the components corresponding to the frequency of 1.04 ~1.39 x 10^{-4}Hz. Fig.2 shows a correlation between the cosmic ray power spectral density averaged

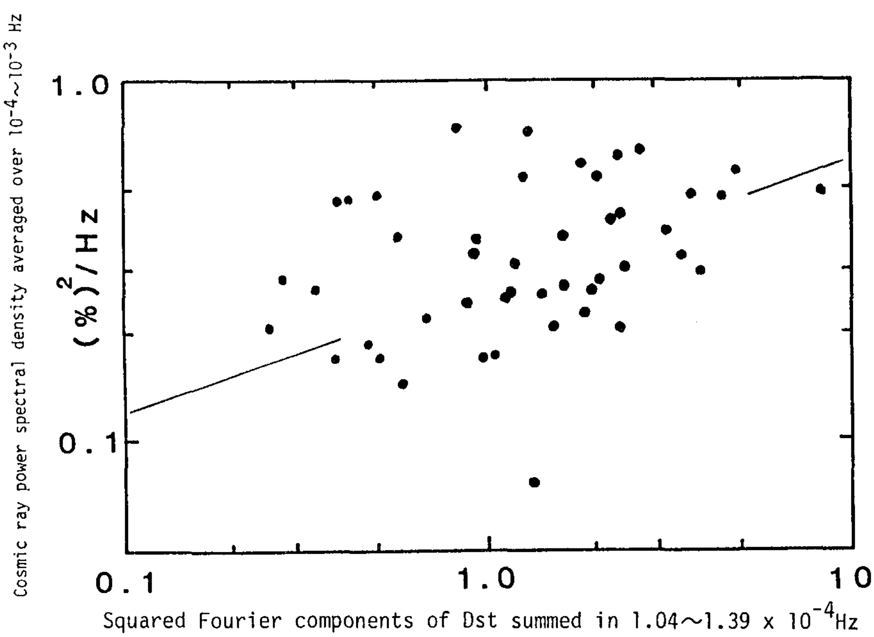

Figure 2. Cosmic ray power spectral density averaged over 10^{-4}~10^{-3} Hz (=y) v.s. squared Fourier components of Dst summed over 1.04~1.39 x 10^{-4} Hz (=x) are shown. The days of analysis are from April 14th to June 13th, 1984. The regression curve is expressed by $y = 0.275\, x^{0.343}$ with the correlation coefficient of 0.48.

over 10^{-4} ~10^{-3}Hz (=y) and the Fourier components summed in the frequency of 1.04 ~1.39×10^{-4}Hz (=x). The relation is expressed by the power law of $y=0.275x^{0.343}$ with the correlation coefficient of 0.48.

3. Conclusions.

1) ~37 minutes periodical oscilations with amplitude of ~0.1% in p-p was observed during the time of 1300 to 1900 UT on April 25th, 1984. This oscilation seems to have good correlation with the geomagnetic field change at Kakioka. The geomagnetic coefficient is ~-0.07%/10nT, consistent with the theoretically estimated value. Hence we conclude that the oscilation occured by the change in cut off rigidities due to Dst field.

2) From the fact of 1), we can expect that the power spectral density of cosmic rays in the frequency range of 10^{-4}~10^{-3}Hz is partly caused by the fluctuation of Dst field. Hence we examined the relation between the power density of cosmic rays and the fluctuations of Dst field around 10^{-4}~10^{-3}Hz by using 1 minute data and 1 hr data respectivery. The regression curve is expressed by $y=0.275x^{0.343}$ with the correlation coefficient of 0.48.

3) From 2), the power spectral density of cosmic rays in the frequency range of 10^{-4}~10^{-3}Hz may be one of good indicators of the fluctuations of Dst field at the same frequency.

4) More reliable conclusion about the correlation will be obtained by increasing day of analysis and also by using other stations.

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5. References.

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