First Zonal Harmonic Component of Cosmic Ray Neutron Intensity

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Abstract

Cosmic Ray neutron data from the cosmic ray stations from the worldwide network in 1966, 1967 and 1969 are analysed by means of the three-dimensional analysis method by Nagashima. The variations of the north-south anisotropy, which is the first zonal harmonic component obtained from the analysis are studied. The result obtained confirms our earlier findings. Relationship of the anisotropy to the IMF sector polarity is also studied.

1. Introduction

We have carried out the analyses of the neutron monitor data in daily mean on the 27 day basis during the years 1966-1969 by means of the Nagashima's method (1971). The first zonal harmonic component of cosmic ray intensity is observed as the North-South (N-S) Asymmetry of cosmic ray intensity and interpreted as the cosmic ray flow in the direction of the earth's rotation axis (Nagashima et al., 1968). We have studied previously such a N-S anisotropy by the method and reported some results (Takahashi et al., 1974: 1979: 1981) on that matter. In this paper, further studies on the subject will be given and discussed in comparison with our earlier results (Takahashi et al., 1974: 1979: 1981). In addition to the above, in this paper, the relationship of a_1^0's to the sector polarity of IMF will be also given and discussed.

2. Method

The method of the analysis has been given previously (Takahashi et al., 1974; 1975; 1984) with particulars. In this paper, a_1^0's for which the power exponential type spectrum having γ=2.0 and P_0=100GV was best-fit in the analysis are used similarly to those in our previous papers (Takahashi et al., 1974; 1975) as a matter of convenience for comparing the results obtained with our earlier results. The data of the Interplanetary magnetic sector polarity are taken from Svalgaard's paper (Svalgaard: 1975).

3. Results and Discussion

(i) Variation of N-S anisotropy, a_1^0

The results obtained are shown in Figs. 1-4. Fig. 1

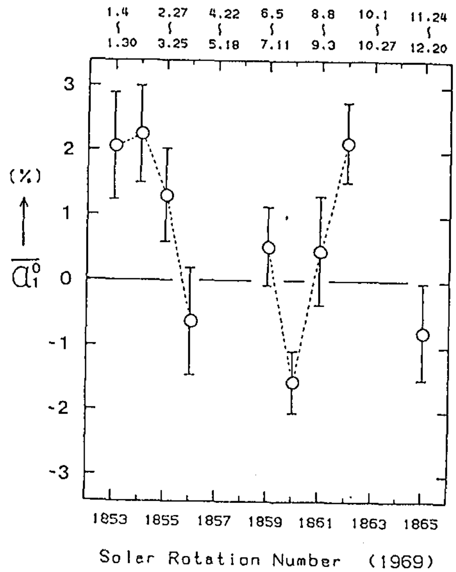

Fig. 1

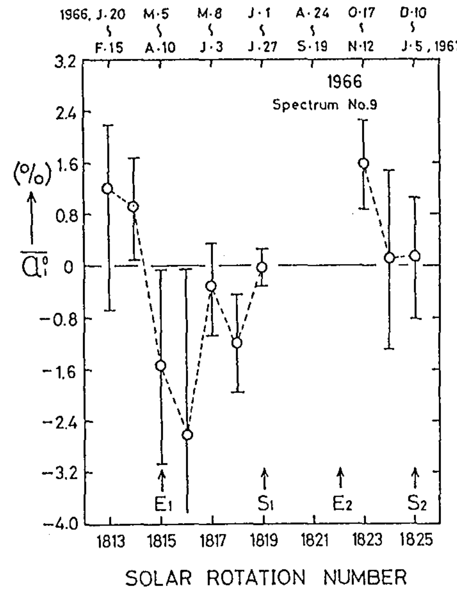

Fig. 2

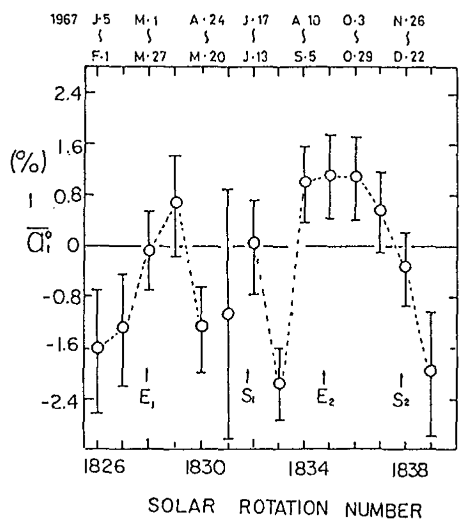

Fig. 3

Fig. 1: The Variation of $\overline{a_1^0}$. $\overline{a_1^0}$ indicates the mean value of a_1^0's during each solar rotation interval in 1969.

Fig. 2: The Variation of $\overline{a_1^0}$, which indicates the mean value of a_1^0's during each solar rotation interval in 1966 (Takahashi et al., 1981).

Fig. 3: The Variation of $\overline{a_1^0}$, which indicates the mean value of a_1^0's during each solar rotation interval in 1967 (Takahashi et al., 1981).

shows the variation of the mean value, $\overline{a_1^0}$, of a_1^0's during each solar rotation during the year 1969. Figs. 2 and 3 are given for comparison of the results obtained here with our earlier results. It will be found that the variation of $\overline{a_1^0}$ shown in Fig. 1 is very similar to that in Fig. 2, whereas there is a marked discrepancy at the period from Rot. No. 1826 to No. 1830 in Fig. 3 between the variations in 1967 and 1969, and at the period from Rot. No. 1831 to 1838, there is a close correlation between them. Although the reason of such a discrepancy is not made clear, it may be due to the difference of physical condition in Space.

(ii) Relationship of a_1^0's to the passages of the positive and negative interplanetary sectors.

Fig. 4 shows the variations of $\overline{a_1^0}$, for the two types of the passages of the interplanetary magnetic sectors, where $\overline{a_1^0}$ indicates the average value of a_1^0 during each solar rotation interval in 1966 and 1969. The figure (Fig.4) is obtained from the Chree analysis, in which the day of passage of the sector boundary is selected as zero day.

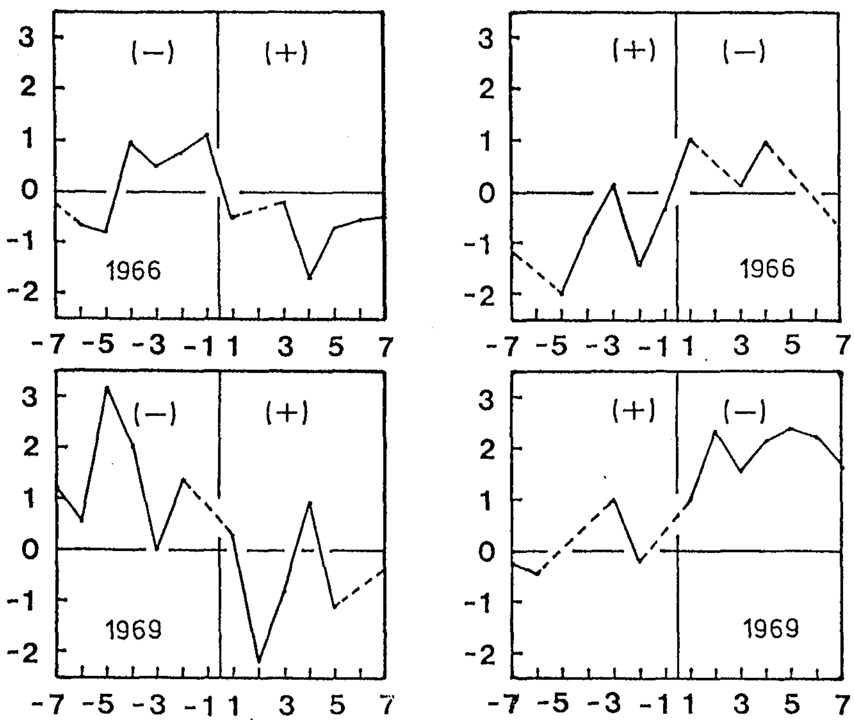

Fig. 4. The variation of $\overline{a_1^0}$ around the passages of the positive and negative interplanetary magnetic sectors where $\overline{a_1^0}$ indicates the average value of a_1^0 during each solar rotation interval in 1966 and 1969.

Yoshida et al. (1971) reported that the N-S anisotropy is related to the interplanetary magnetic sector structure. They also showed that the N-S anisotropy is, on an average, positive in the toward (-) sector (i. e. excess fluxes from the northern polar region), whereas the N-S anisotropy is negative in the away (+) sector (i. e. excess fluxes from the southern polar region (Yoshida et al., 1973). Our results (Fig. 4) are consistent with those by Yoshida et al. (1973). As for the mechanism of the N-S anisotropy, it is reported that the B×∇n mechanism gives a negative N-S anisotropy due to the outward direction of $B_{\parallel}$ (positive $B_{\parallel}$). Also the inward $B_{\parallel}$ produces a positive N-S anisotropy (Tolba, 1974). Pomerantz and Bieber (1984) also showed that the N-S anisotropy is prepondarantly positive, as expected if it arises from a positive radial gradient via the B×∇n drift mechanism. Such a mechanism is also applicable to our results obtained here.

4. Conclusions

The following conclusions from the results shown the above may be drawn:

(1) The first zonal harmonic component (N-S anisotropy) derived from the three-dimensional analysis method by Nagashima makes a yearly variation on an average during a solar rotation interval.

(2) The first zonal harmonic component (N-S anisotropy) derived from the three-dimensional analysis by Nagashima's method makes a variation closly related to the passages of the interplanetary magnetic sectors on an average during a solar rotation interval. The variation depends on the sector polarity.

(3) Such a variation may be interpreted by the $B \times \nabla n$ mechanism.

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