Energy Commision.
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CHANGE IN THE RIGIDITY SPECTRUM DURING SHORT-TERM VARIATION OF COSMIC RAYS

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In this paper, we discuss briefly a change in the rigidity spectrum during short-term variation of cosmic rays. McCracken[1] investigated the variations in the cosmic-ray rigidity spectrum during the short-term variations by using b_{12} and b_{21} evaluated from the data at Hobart ($\lambda = 52°$S) and Lae ($\lambda = 16°$S). b_{12} and b_{21} are the linear regression coefficients calculated for a scatter diagram (as shown in Fig. 1) of neutron intensity against meson intensity at Hobart, or of neutron intensity at Hobart against neutron intensity at Lae. In the scatter diagram, these intensities were expressed as the percentage deviations from the mean value of the cosmic-ray intensity during each short-term variation.

From the author's investigation,[2] it is expected that the values of b_{12} and $1/b_{21}$ must correlate with geomagnetic disturbance during the short-term period. In order to investigate the correlations, we compared the values of b_{12} and $1/b_{21}$ with the mean value ($\langle Ap\rangle_{av}$) of the Ap index during each short-term period. Ap is an index indicating the amount of the geomagnetic disturbance observed on the earth, but it is assumed that this index is

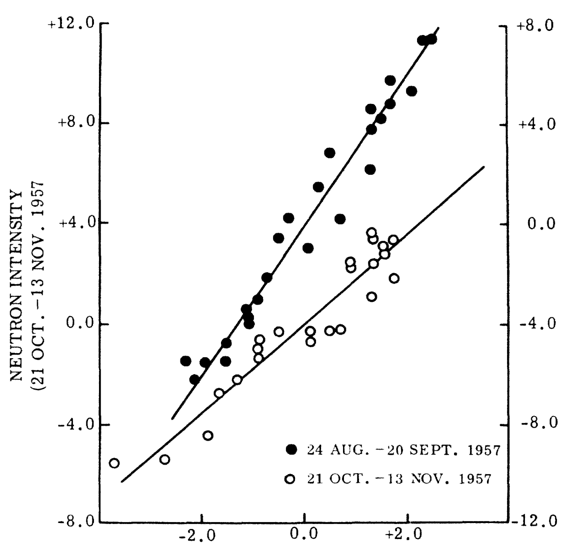

FIG. 1. Scatter diagram of Hobart neutron intensity against Hobart meson intensity for two short-term variations. Percentage deviations from the group mean are plotted. (After McCracken.[1])

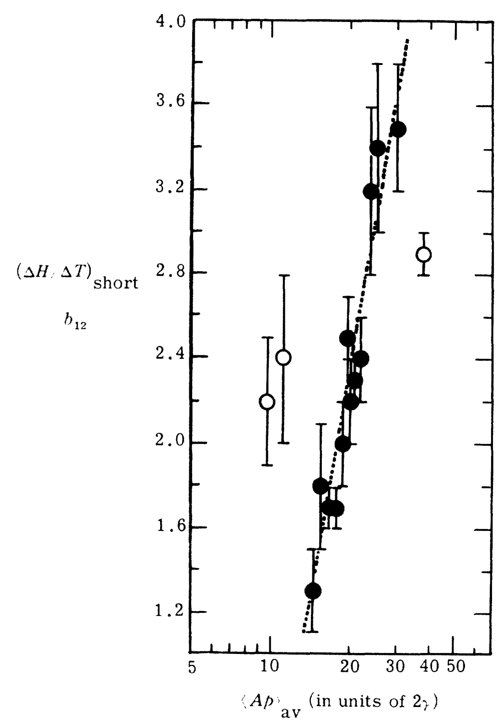

FIG. 2. Dependence of the relative changes of meson and neutron intensities of cosmic rays at Hobart on geomagnetic disturbance. b_{12} indicates the regression coefficient between Hobart neutron intensity and Hobart meson intensity.

also dependent on the property of the magnetic cloud emitted from the sun. One of the results obtained is shown in Fig. 2. The other results are similar to this. The correlation coefficient between the corresponding two quantities in Fig. 2 is 0.97, which is sufficiently significant. In this case, however, the three isolated points designated by open circles, which were assumed to be exceptional cases, were omitted in the calculation. Then it is evident that the values of b_{12} and $1/b_{21}$, that is, the relative change of the cosmic-ray intensity, has a good correlation with $\langle Ap\rangle_{\rm av}$.

From these, it is concluded that the cosmic-ray rigidity spectra change exponentially with geomagnetic disturbance in the short-term period, and such changes are supposed to be caused mainly by magnetic clouds emitted from the sun.

A detailed description of the study is to be published in the near future.

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IMPULSE APPROXIMATION AND DISTORTED WAVES*

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In the theory of the inelastic scattering of a nucleon by a nucleus at high energies, the following approximate expression for the scattering amplitude is often used:

$$F_{fi}(\vec{k}_f,\vec{k}_i) = -(2\pi)^2\frac{m}{\hbar^2}\left(\frac{A}{A-1}\right)\left(\frac{K_f}{K_i}\right)^{1/2} T_{fi};$$

$$T_{fi} = \int \chi_{fU}^{(-)*}(\vec{r})u_f^*(1\cdots A)\left[\sum_{i=1}^{A} t(\vec{r}-\vec{r}_i)\right]\chi_{iU}^{(+)}(\vec{r})u_i(1\cdots A)d\vec{r}d\vec{r}_1\cdots d\vec{r}_A. \quad (1)$$

Here $t(\vec{r})$ is the transition matrix describing the scattering of two free nucleons,

$$t(\vec{r}) = v(\vec{r})\left[1+\frac{1}{E-K(r)+i\epsilon}t(\vec{r})\right], \quad (2)$$

where $K(r)$ is the kinetic energy. The wave function $\chi_{iU}^{(+)}(\vec{r})$ consists of the incident plane wave being distorted by a one-particle complex potential $U(\vec{r})$,

$$\chi_{iU}^{(+)}(\vec{r}) = \left[1+\frac{1}{E-K-U(\vec{r})+i\epsilon}U(\vec{r})\right]\exp i\vec{k}_i\cdot\vec{r}. \quad (3)$$

The assumptions contained in Eq. (1) are, first, that the inelastic scattering is a direct process, so that the two-particle interaction appears only linearly in the expression for the scattering amplitude; second, that the two-particle interaction can be replaced by the free two-particle transition matrix (which is essentially the two-nucleon scattering amplitude). This latter approximation is the impulse approximation. In addition, the distorting potential may be taken to be the optical potential describing elastic scattering, in which case it is given by the expression

$$U(\vec{r}) = (A-1)\langle iti\rangle = (A-1)\int u_i(1\cdots A)t(\vec{r}-\vec{r}_1)u_i(1\cdots A)d\vec{r}_1\cdots d\vec{r}_A. \quad (4)$$

Our main purpose is to obtain an expression for $F_{fi}(\vec{k}_f,\vec{k}_i)$ in which the leading term is given by Eq. (1). We shall show how to eliminate troublesome terms which involve the mixing of the two-body interaction