§5. Conclusion

We find a good agreement between the incident energy and the energy dissipated, taking into account the underestimation in the nuclear disintegration. In fact, at Saskatoon about 50 MeV cm^{-2} sec^{-1} sterad^{-1} may be added to the preceding value. Therefore, adopting the revised energy spectra, one could expect a good agreement between them at any place. If it is so, the fact that the pure dipole geomagnetic field theory does not well explain the phenomena would be also derived from this point of view.

The author wishes to express his cordial thanks to Professor K. Nagashima for valuable discussions.

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INTERNATIONAL CONFERENCE ON COSMIC RAYS AND THE EARTH STORM Part II

II-4-21. On the World-wide Distribution of the Daily Variation of the Cosmic-Ray Neutron Intensity and Its Variation

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The world-wide distribution of T_m (the local time of maximum in the diurnal variation of cosmic-ray intensity) was derived from the data during the period of I.G.Y. and was compared with that calculated theoretically. The following results were obtained. (1) Cosmic-ray particles seem to have an anisotropy in the direction of 17 hr (L.T.) far away, and to be modulated in the direction of 12 hr (L.T.) within the solar clouds in the interplanetary space. (2) The lines of force of the geomagnetic field may be assumed to bend westwards in the outer space of the earth. (3) The cosmic-ray equator may be changing from time to time.

§1. Introduction

If the time variation of the world-wide distribution of cosmic-ray intensity is measured continuously and thoroughly, we can easily carry out analysis to find the mechanism of the modulation of cosmic rays in the interplanetary space. However, it is rather difficult, at present, to normalize the counting rate which is observed by each cosmic-ray monitor at every station in the world.

As the first step to take a wide view of cosmic-ray phenomena, one of the authors (T. K.)[1] derived the world-wide distribution of the time of maximum in the diurnal variation of cosmic-ray intensity (T_m). The time variation of the distribution of T_m was also taken into account for the data in I.G.Y.. T_m was used because it can be treated without regard for the normalization of counting rate.

One of the authors (K. M.)[2] calculated the world-wide distribution of T_m theoretically. He considered the difference between the axis of rotation and that of geomagnetic dipole moment as well as the energy dependence of the amplitude of anisotropy.

The world-wide distribution of T_m calculated theoretically is compared with that derived experimentally, and described below.

§ 2. Procedures of Analysis

The stations were classified into two groups; the one is the *mountain altitude group* (M.A.) ($\geq$2000 m above sea level), the other the *sea level group* (S. L.) (<2000 m above sea level).

The number of the stations, which were used here, are shown in Table I.

Table I. Number of stations used in this work.

Period	S.L.	M.A.	Total
July-December, 1957	30	9	39
January-June, 1958	35	10	45
July-December, 1958	35	10	45

T_m was derived by the following methods.

(1) The bi-hourly readings[3], represented by the procedure of Wada[4], were averaged over a period of a month, excluding all data of the imperfect days, and only the months having more than ten perfect days were employed.

The harmonic analyses were carried out on these monthly mean diurnal variation, and the first term $\boldsymbol{R}_1$, the second term $\boldsymbol{R}_2$, the third term $\boldsymbol{R}_3$, and so on were obtained. Then, the averaged value of T_m of each month will be obtained from $\boldsymbol{R}$ to be shown as follows.

$$\boldsymbol{R}=\boldsymbol{R}_1+\boldsymbol{R}_2+\boldsymbol{R}_3+\cdots$$

However, we neglected the third term and the higher order terms, because it was confirmed that they had only few effect on T_m.

(2) The averaged values of T_m's during the period of each half a year were derived from the averaged values of the vector sum of harmonic vectors of the six months during each period of half a year.

Meanwhile, the distribution of T_m was calculated theoretically under the consideration of the eccentric and inclined geomagnetic dipole field under the various assumption of the energy dependence of the amplitude of anisotropy[2].

§ 3. Results and Discussion

1. *Latitude Effect and Longitudinal Effect of T_m*

The geomagnetic latitude-effect of T_m becomes clearer when the sea level group is plotted separately from the mountain altitude group. The sea level group advances from

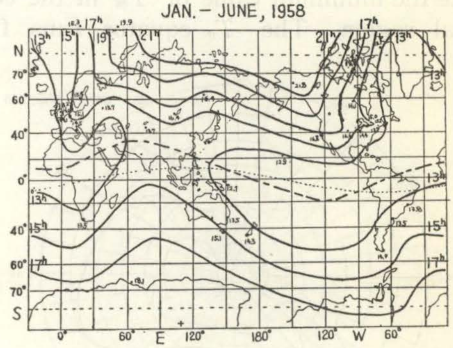

Fig. 1. Contours of T_m during the period of January–June, 1958. The heavy chained line shows the cosmic-ray equator determined by T_m. The fine dotted line shows the geomagnetic equator. Numbers attached at stations and contours show T_m (in units of hour) belonging to them, respectively.

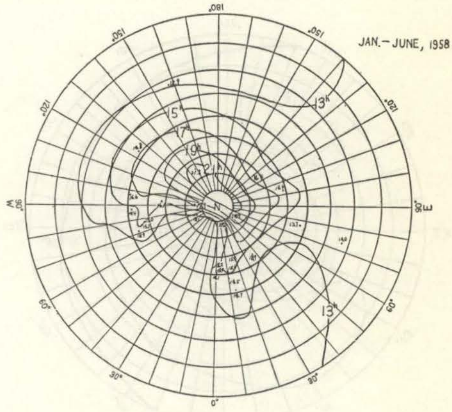

Fig. 2. Contours of T_m on the northern hemisphere during the period of January–June, 1958. Numbers attached at stations and contours show T_m (in units of hours) belonging to them, respectively.

the one in the mountain altitude group in lower latitude. There is some evidence that T_m-min (the minimum value of T_m in the latitude-effect curve of the sea level group) and the magnitude of the latitude effect of T_m vary from month to month. There is a tendency that advance of Tm min and the increase of the magnitude of the latitude effect of Tm relate to the increase of solar activity. There is also the longitude effect of T_m.

2. World-wide Distributions of T_m's

In order to clear up the above facts, contours of T_m were drawn in the world map. From Fig. 1 (Mercator's projection), one can trace the minimum value of T_m in the equatorial region. The T_m-equator runs from

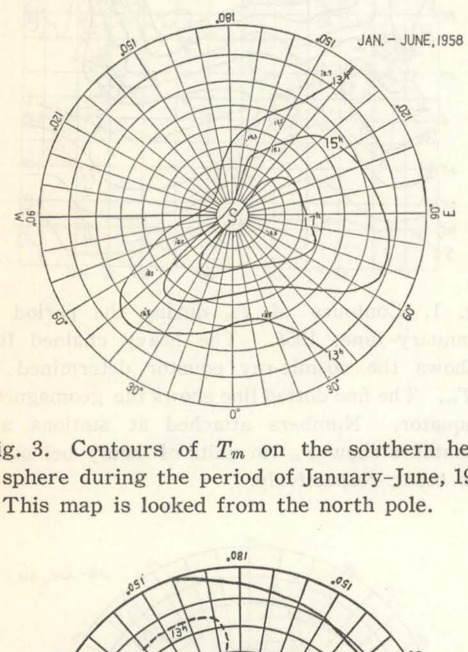

Fig. 3. Contours of T_m on the southern hemisphere during the period of January–June, 1958. This map is looked from the north pole.

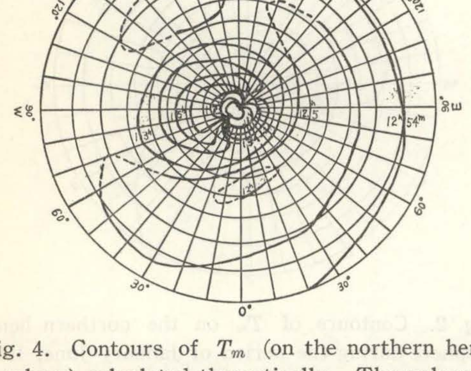

Fig. 4. Contours of T_m (on the northern hemisphere) calculated theoretically. The values in figure indicate T_m when the anisotropy is in the direction of 17 hr from the earth.

the Pacific Ocean to the South Africa passing through the South America.

In order to obtain detailed information of polar regions, contours of T_m were drawn in the northern and the southern hemispheric maps as shown in Figs. 2 and 3.

There was some westwards and eastwards change in the northern hemisphere during I.G.Y., but no definite time variation in the southern hemisphere.

Fig. 4 shows one of the calculated contours of T_m's in which the anisotropy is assumed to be in the direction of 17 hr (L.T.). At a glance, the calculated contour map of T_m (Fig. 4) is very different from the observed one (Fig. 2). However, when the calculated map is turned a little westwards, the maps show a fair agreement.

3. Cosmic-Ray Equator Determined by T_m

There are the minimum points of T_m between the northern and the southern hemisphere. The trace of minimum points of T_m can be said "the equator of T_m". Though we can not trace the cosmic-ray equator existed during I.G.Y., from the investigation of the equator of T_m, it may be able to suggest that the cosmic-ray equator is also changing from time to time.

§4. Conclusions

From the results and discussion mentioned above, some conclusions are deduced as follows.

(A) From comparison between the calculated and the observed contours of T_m, it may be able to say that the cosmic rays may have an anisotropy in the direction of 17 hr (L.T.) far away, and, from the time-variation of the observed contours of T_m, it may be able also to say that they may be modulated for the direction of 12 hr (L.T.) within the solar clouds in the interplanetary space.

(B) From comparison between the observed contours and the calculated ones, it may be able to say that the lines of force of the geomagnetic field may be bended westwards by the solar emission in the outer space of the earth.

(C) Of course, perhaps, the cosmic-ray equator may differ from the T_m-equator, but it may be proper to assume that the cosmic-ray equator may be moving with time because the cosmic rays may be modulated by the solar clouds in the interplanetary space.

At the end, it will be hoped that the cosmic-ray neutron intensity will be measured simultaneously by the apparatus with the same type and size on many stations over the world in the near future, and then it will be able to expect to obtain easily an information of the location of the cosmic-ray equator, and of the modulation in the interplanetary space from the time variations of the world-wide distributions of cosmic-ray intensities.

§ 5. Acknowledgment

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Discussion

Sandström, A. E.: What accuracy do you affix to the curves you have shown?

Kanno, T.: $\sim\pm 0.5$ hr.

Kondo, I.: This work has an important meaning, because of the following reasons. The diurnal variation is considered to be due to rather high energy cosmic rays, then the distribution of the time of maximum on the earth will give a valuable knowledge to study the shape of geomagnetic field far from the earth (6~10 *Re*). Then with the complement to the study of the distribution of cut-off or of the mean intensity on the earth, this study will give a complete picture of geomagnetic field and its effect on cosmic rays.