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INTERNATIONAL CONFERENCE ON COSMIC RAYS AND THE EARTH STORM Part III

III-2-17. Intensity Distribution of High Energy Cosmic Rays on the Celestial Sphere*

I. KONDO, T. MURAYAMA, S. MORI, H. OKUDA,
S. SAKAKIBARA and Y. SEKIDO

Physical Institute, Nagoya University, Nagoya, Japan

Using newly built Cosmic-Ray Telescope No. 3 (gas Cerenkov telescope), observation was made to study the intensity distribution of high energy ($>10^{11}$ eV) cosmic ray primaries on the celestial sphere.

The celestial sphere ($-44° < \delta < 74°$) was divided into many parts of about 10^{-2} steradian, and the cosmic ray intensity in each part was measured with a statistical accuracy of $\pm 6\%$. Comparing the results obtained by duplicate telescope tubes, the observed anisotropy was studied statistically.

Apart from the scanning, observation with higher statistical accuracy has been made in several regions of the sky containing astronomical objects of special interest.

§1. Introduction

It is generally believed that the cosmic rays arrive at the earth nearly isotropically from all directions regardless of their energies. Besides the anisotropy produced by solar modulation, the degree of anisotropy was found to be smaller than 10^{-3} for energies up to 10^{15} eV. These results, however, are obtained only with cosmic ray detectors of wide resolving angle (about one steradian or more), and therefore anisotropy in a small solid angle ($\lesssim 10^{-2}$ steradian) could not be observed by these instruments.

To investigate the existence of such a sharp anisotropy, the detectors must have a narrow angular resolution and an ability of selecting high energy particles because of following reasons:

1) The direction of the primary cosmic-ray particles will be largely deviated from the original direction by geomagnetic field when they are charged particles of energies lower than 10^{11} eV.

2) The initial direction of the primary particle will be conserved only by high energy secondaries in the nuclear interaction of primary particles with air nuclei. Mean angle between the direction of secondary mesons and that of primary particle is estimated to be 0.5 radian/E_m, where E_m denotes the energy of the meson in GeV. In order to keep the mean deflection angle less than 0.1 radian, it is necessary to select mesons of energies larger than 10 GeV at the production layer. Furthermore, the detector itself should have an ability to reject low energy particles scattered into the detector.

An experiment to study the existence of "sharp" anisotropy was performed by Sekido *et al*[1]) with a narrow angle G. M. Telescope. In this experiment, the zenith distance of the telescope axis was fixed to 80° in order to filter out mesons of energies lower than 12 GeV at the production layer by thick air traversed. Also an iron absorber of 2 meters thick was inserted between the G. M. trays to exclude mesons of energies lower than 2 GeV scattered in the atmosphere. The mean energy of the primary particles which produce the μ-mesons observed was estimated as 300 GeV.

From the result of two years of observation, they have shown that some anisotropies must exist in the distribution of the cosmic-ray intensity on the celestial sphere. But owing to a very small detecting area of the telescope, the above results were obtained only statistically and any particular sources could not be found from the observation. This telescope and another G.M. telescope (No. 2) were used to study the intensity variation of a point source in Orion since 1954, hence further study for other sharp anisotropies was not continued.

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Recently a large detector with narrow angular resolution and high energy threshold was constructed in this laboratory, and was named as Telescope No. 3[2]. Using this telescope, the study for the sharp anisotropy was begun in Feb. 1961. Preliminary results of this observation will be described below.

§ 2. Procedure of Scanning

In the observation with Telescope No. 3, the direction of primary cosmic-ray particles can be observed within the error of 5° because of followings:

1) The resolving angle of the sub-telescope is 7°ϕ or 7°×5°.

2) The minimum energies of the particles detected by the telescope are 5 GeV for μ-mesons and 200 MeV for electrons, respectively.

The distributions of the cosmic-ray intensity over the celestial sphere was observed by this telescope under the following conditions:

1) The zenith distance of the telescope axis was kept at Z=75° throughout the observation. Consequently, the average energy of primary protons is about 300 GeV. The average rate of the sub-telescope is about 15/min. The counting rates during every 20 minutes are recorded for each sub-telescope. The root mean square for 20 minutes values is about 6%.

2) The azimuthal direction of the telescope is fixed to a certain azimuth throughout a sidereal day. Then a band of the sky having the declination between certain limits was scanned by the telescope, for the total field of view is a circle of 15° diameter. For an example, when the telescope is pointed to $A=84°$, the sky between $\delta=6°$ and $\delta=21°$ is scanned by the telescope.

3) 30 directions in 12° intervals were chosen as the azimuthal angles to which the telescope axis was set. So the same declination band was scanned twice during a series of observation; *i. e.*, one in the eastern azimuth and another in the western azimuth. Thus, the sky between $\delta=44°S$ and $74°N$ was scanned at Nagoya, 35°N in geographic latitude.

4) The telescope has duplicate telescope tubes which detect cosmic-ray particles and record them independently. So the results obtained by the two tubes can be compared each other.

5) Two series of the observation were carried out; the first in Feb.-Mar. 1961 and the second in Jun.-Aug. 1961.

§ 3. Results

The intensity distribution over the celestial sphere by sub-telescopes which is pointing to $Z=74°$ was studied statistically. First, the map of intensity distribution was made. The intensity observed at a section (7°×5°) is compared with the average of the intensities in the same declination. The difference between the observed rate N and the average N_0 was classified by $D=(N-N_0)/N_0^{\frac{1}{2}}$ and plotted on a map. This map was made for four independent observations; *i.e.*, the two telescope tubes (R and L) and the two azimuthal directions (*East* and *West*) during a series of observation.

When $D>2$ at a certain section of the map,

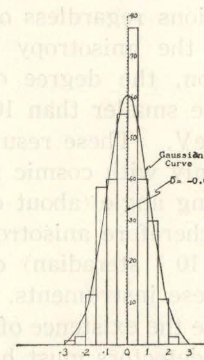

Fig. 1. Frequency distribution of D by a tube in the sections where the corresponding D values by the other tube are larger than 2 (For first series).

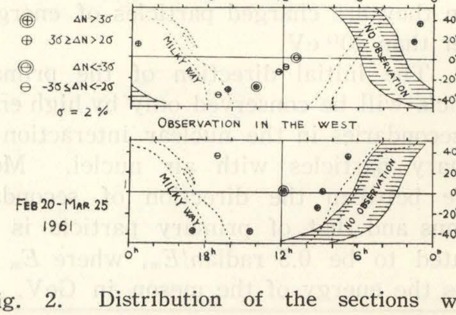

Fig. 2. Distribution of the sections where counting rates are largely deviated from the mean value ($|D|>2.5$).

for example by a telescope tube L, the corresponding rate observed by the other telescope tube R probably be larger than the average if the former deviation is due to an anisotropy. Fig. 1 shows the distribution of D observed by R or L in the sections corresponding to those where $D>2$ in the observation by the other telescopes. As seen from the figure, almost all of the deviation can be attributed to the statistical fluctuations with the standard deviation of 6%.

After adding two independent observations by L and R tubes, the intensity distribution of the cosmic ray over the celestial sphere of unit section $10° \times 10°$ were obtained. In this distribution, the parts of the sky which gave counting rates as large as $|D|>2.5$, *i.e.*, $|N-N_0/N_0|>5\%$, were marked in the map shown as Fig. 2. The maximum of observed D values in the map was 3.5 for the first series.

Apart from the scanning, observation with higher statistical accuracy has been made in several regions of the sky containing astronomical objects of special interest, such as *Tau*. A, *Cas*. A, *Cyg*. A. At present, any significant results were not yet obtained.

References

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III-2-18. A Gas Cerenkov Cosmic-Ray Telescope

Y. SEKIDO, I. KONDO, T. MURAYAMA, S. MORI, H. OKUDA, S. SAKAKIBARA, T. MAKINO, and T. HONZAWA

Physical Institute, Nagoya University, Nagoya, Japan

A cosmic-ray telescope was built based on an idea to detect high energy cosmic-ray charged particles by observing gas Cerenkov radiation emitted by them in a closed vessel without aid of any other particle detectors. Individual μ-meson ($E>10^{10}$ eV) was detected with sufficiently high efficiency (~95%) and with narrow angular resolution ($7°\phi$) in a wide scope ($15°\phi$). The telescope was built on an alt-azimuth mounting (azimuthal angle $0°\sim360°$, zenith distance $0°\sim90°$), and has a large detection area (20 m^2), so it can be used to observe the intensity of cosmic rays coming from nearly horizontal direction with appreciable accuracy.

This telescope was planned and constructed for the study of the anisotropy of primary cosmic rays. It can be used also for the study of the time variation of cosmic ray intensity and for any other experiments to detect high speed charged particles of very low flux density.

§ 1. Introduction

Two cosmic-ray telescopes were built at Nagoya. Telescope No. 1 in 1951 and Telescope No. 2 in 1955, respectively[1]. They are G. M. counter telescopes mounted on alt-azimuth mountings, with thick iron absorbers. These telescopes were used for the study of the anisotropy of primary cosmic radiation.

In the course of this study, a new telescope with larger detecting area became necessary. Since the detecting area of Telescope No. 2 is 0.5 m^2, it was hoped that the

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