JOURNAL OF THE PHYSICAL SOCIETY OF JAPAN Vol. 17, SUPPLEMENT A-III, 1962
INTERNATIONAL CONFERENCE ON COSMIC RAYS AND THE EARTH STORM Part III

III-2-16. Observation of the Point Source of Cosmic Rays*

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Further observations on the cosmic-ray intensity from the point source in Orion has been made by G-M counter telescopes (No. 1 and No. 2) since 1959, and discussed in connection with the results reported at the Moscow Conference.

In recent two years, the intensity of the point source looks slightly higher than in the period 1957-1958, but is not significantly positive and much lower than that in the period 1954-1956. From this result, a hypothesis presented at the Moscow Conference is not likely, in which it was assumed that the intensity of the source was proportional to the luminosity of W-Orionis and was expected to be high in 1960.

Since Feb. 1961, the observation by a large cosmic-ray telescope (Telescope No. 3) has been started. In this period, the intensity of cosmic rays in the direction of the point source was $+0.63\%\pm0.27\%$ by Telescope No. 3 and $+3.0\%\pm2.1\%$ by Telescope No. 2, respectively, compared with the mean intensity.

§1. Introduction

During the period from 1954 to 1956, a point fource of cosmic rays was observed by Sekido et al[1] at a certain position in Orion. The diameter of the image was smaller than 5°, while the intensity was more than 10% of the mean background intensity, and the mean energy of the primary rays was estimated to be about $3\cdot10^{11}$ eV. But there was no evidence to support the location of the source nor the explanation for the mechanism of propagation through the galactic magnetic field.

The observation was continued but the image disappeared in 1957 and 1958, as reported at the Moscow meeting[2]. At that time, an explanation of such time variation of the source intensity was suggested by Murayama[3] in which it was assumed that the observed source was due to γ-rays from a variable star W-*Orionis* which was at

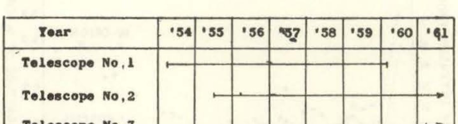

Fig. 1. Period of observation by each telescope.

* This paper was combined with III-2-17 and III-2-1-18, and presented by Y. Sekido in III-2-20.

maximum magnitude in 1954.

Since 1959, the observation was still continued as shown in Fig. 1. The Telescope No. 3[4] is a new telescope which was built to get higher accuracy of the cosmic-ray observation by using larger detecting area as shown in Table I.

Table I

Telescope	No 1.	No. 2	No. 3
Method	G-M counter	G-M counter	Gas Cerenkov
Field of view	5°×5°	5°×40°	15°
Resolving angle	5°×5°	5°×4°	7°
Detecting area	0.1 m²	0.5 m²	20 m²
Counting rate at Z=80°	3 hr⁻¹	15 hr⁻¹	500 hr⁻¹

There are two aims in the observation after 1959. The first is to know whether the point source re-appears or not when W-*Orionis* becomes lumimous again. In September 1960, when the star showed the maximum luminosity in recent six years, however, no remarkable increase of cosmic-ray intensity was observed in the position of the point source determined in 1954-56. The second is to observe the detailed characteristics of the point source with aid of the large area telescope when the source shows high intensity again. From 1961, accuracy of the observation was improved since the operation of Telescope No. 3 has started. From the observations until August 1961, it is not yet clear that there was reappearance or not, and the observations are still in continuation. Here, preliminary results are described at the occasion of Kyoto Meeting.

§ 2. Continuation of the Observation with G-M Telescopes

During the period 1954–56, the image of the point source appeared in each of the two kinds of observation, *i.e.*, "*East*" and "*West*" (Table II). As shown in the previous paper[2], the two images (*E*- and *W*-image) were identified to each other, *i.e.*, they were considered as the image of one point source because the difference in their positions was explained as the result of different geomagnetic deflections at the two azimuthal angles. This identification was possible by any of the three assumptions described in § 3. Therefore, the intensities observed at both images are averaged and the averaged intensity was compared with those at other positions of the same declination as shown in Fig. 2.

As seen in this figure, a remarkable point source was observed in 1954–56, but not after 1957. To see the time variation of the cosmic-ray intensities from the point source, the monthly values of intensity excess at this position are plotted in Fig. 3. As seen in this figure, the intensity excess around September 1960 is negligibly small compared with that around April 1954, while the luminosities of W-*Orionis* in these two periods were nearly the same as shown in Fig. 4. Therefore, the cosmic-ray intensity from the point source is not likely proportional to the luminosity of W-*Orionis*.

In Fig. 3, the intensity excess seems to be slightly positive in 1960–61, but not clear in its large statistical error. This will be re-

Table II

		E-image	W-image
Condition of observation	Azimuth from the north (A)	85°	225°
	Zenith distance (Z)	80°	80°
	Sidereal time	23^h40—23^h40	9^h30^m—9_h50_m
Direction of image	Right ascention (α)	4^h56^m	4^h51_m
	Declination (δ)	10.7°	−5.3°

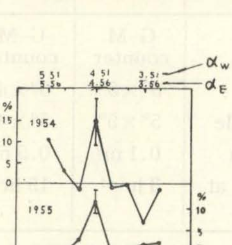

Fig. 2. Yearly averaged values of the cosmic-ray intensity excess near the position of the point source.

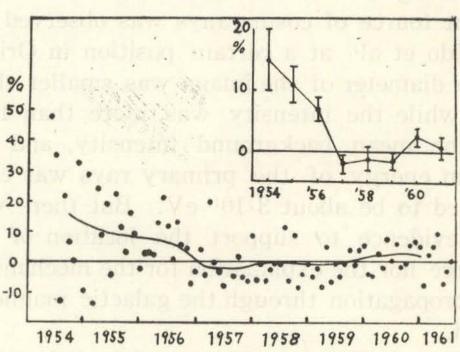

Fig. 3. Monthly averaged values of the intensity excess at the position of the point source.

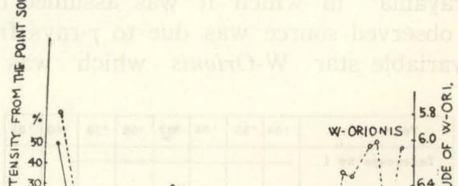

Fig. 4. Cosmic-ray intensity from the point source and the luminosity of W-Orionis.

ferred to in § 4 together with the results obtained by Telescope No. 3.

As reported previously, intensity of the source showed a periodic variation with a period of about 18 days in 1954–56. The amplitude of the variation was deduced in every year assuming the 18 days periodicity and plotted in Fig. 5. together with the yearly average of the intensity excess.

Telescope No. 2 has a wide field of view as shown in Table I and ten declination bands are observed simultaneously by sub-telescopes in it. The observed range of declination was not fixed in the period 1955–61 as shown in Fig. 6 and the intensity distribution in the declination range observed throughout the whole period is shown in Fig. 7. The central declination band in each map in Fig. 7 contains the position of the source, the

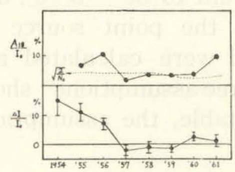

Fig. 5. Yearly values of the intensity excess at the position of the point source and its amplitude of 18 days periodicity.

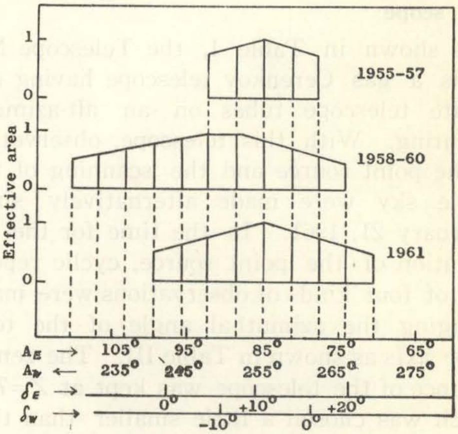

Fig. 6. Azimuthal dependence of the effective area Telescope No. 2.
A_E: Azimuthal angles in the "East" observation.
A_W: Azimuthal angles in the "West" observation.
δ_E, δ_W: Declinations corresponding to A_E and A_W, respectively.

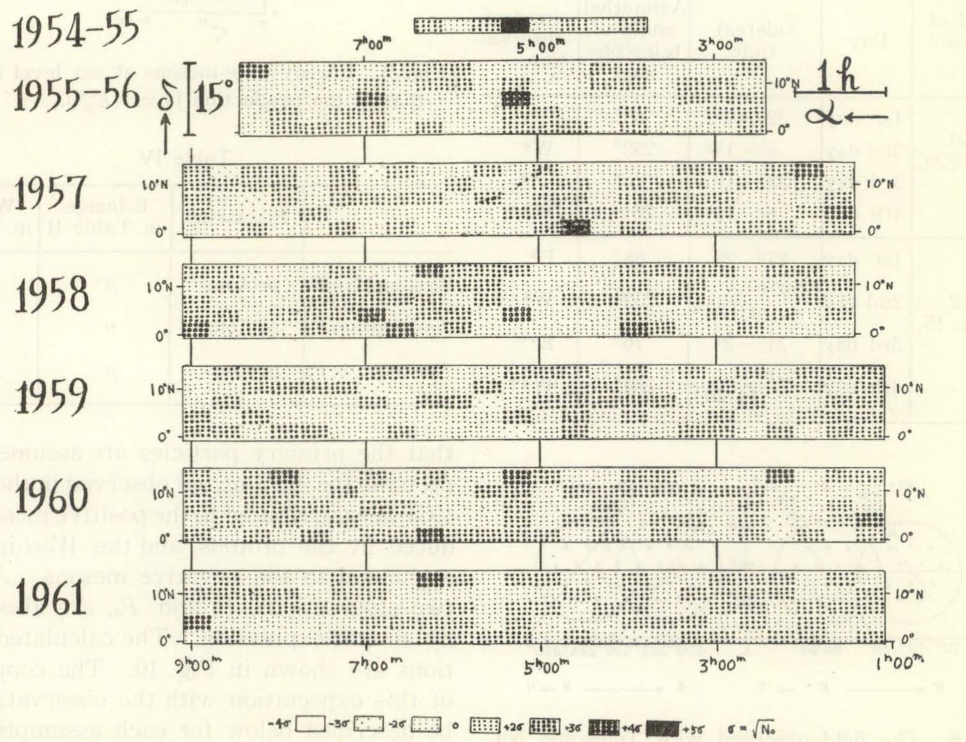

Fig. 7. Intensity map of cosmic rays observed with Telescope No. 2 (1955–1961). (α, δ): Fquatorial coordinates under the assumption P_1 (see § 3).

detailed intensity distribution in this band being already shown in Fig. 2.

§ 3. Observation with a Gas Cerenkov Telescope

As shown in Table I, the Telescope No. 3[4] is a gas Cerenkov telescope having duplicate telescope tubes on an alt-azimuth mounting. With this telescope, observation of the point source and the scanning of the whole sky were made alternatively since February 21, 1961. In the time for the observation of the point source, cyclic repetition of four kinds of observations were made changing the azimuthal angle of the telescope axis as shown in Table III. The zenith distance of the telescope was kept at $Z=75°$, which was chosen a little smaller than that of the telescope No. 2 in order to compensate the difference in the instrumental cut off energies for μ-mesons. The field of view of the Telescope No. 3 is a circle of $15°\phi$, while the resolving angle is a circle of $7°\phi$, because the telescope includes twelve sub-telescopes. The zenith distance Z and the azimuthal angle A of each sub-telescope determined by the schedule above described are shown in Fig. 8.

Table III. Schedule of observation of the point source with Telescope No. 3

Period of observation	Day	Sidereal time	Azimuthal angle of telescope axis	kind of observation
Feb. 21 —Apr. 25, 1961	1st day	22^h—1^h	88°	E*
	2nd day	8^h—11^h	252°	W*
	3rd day	22^h—1^h	76°	E**
	4th day	8^h—11^h	264°	W**
Jun. 12 —Aug. 15, 1961	1st day	21^h—2^h	88°	E*
	2nd day	7^h30^m—11^h30^m	252°	W*
	3rd day	21^h—2^h	76°	E**
	4th day	7^h30^m—11^h30^m	264°	W**

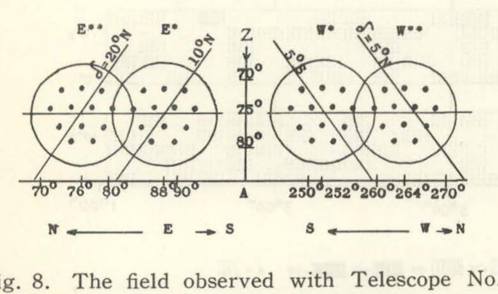

Fig. 8. The field observed with Telescope No. 3 shown in the horizontal coordinate system (Z, A).

Before comparing the results obtained by Telescope No. 3 with that of Telescope No. 2, the difference in the geomagnetic deflections must be considered. The cut off energy of μ-mesons observed with Telescope No. 3 is considerably higher than that with Telescope No. 2 as shown in Fig. 9, and the figure suggests that the primary energy for Telescope No. 3 will be a little higher than for Telescope No. 2. Taking these differences into account and assuming the power of the energy spectrum to be $-(5\sim6)$, deviations of the image of the point source in the geomagnetic field were calculated according to each of the three assumptions[2] shown in Table IV. In this table, the assumption P_1 means

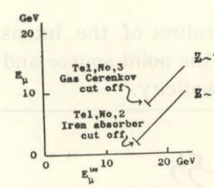

Fig. 9. Energy of μ-mesons at sea level (E_μ) vs. that at the production layer (E_μ^{100}).

Table IV

	Primaries	E-image in Table II	W-image in Table II
Assumption P_1	protons	μ^+	μ^-
Assumption P_2	protons	μ^-	μ^+
Assumption P_0	protons	μ^+	μ^+

that the primary particles are assumed to be protons, the *East*-image observed in the period 1954–56 is attributed to the positive mesons produced by the protons, and the *West*-image is attributed to the negative mesons. Another two assumptions, P_2 and P_0, are also shown by similar expression. The calculated deviations are shown in Fig. 10. The comparison of this expectation with the observation will be described below for each assumption.

In the first place, examination was done under the assumption P_1. The field of view

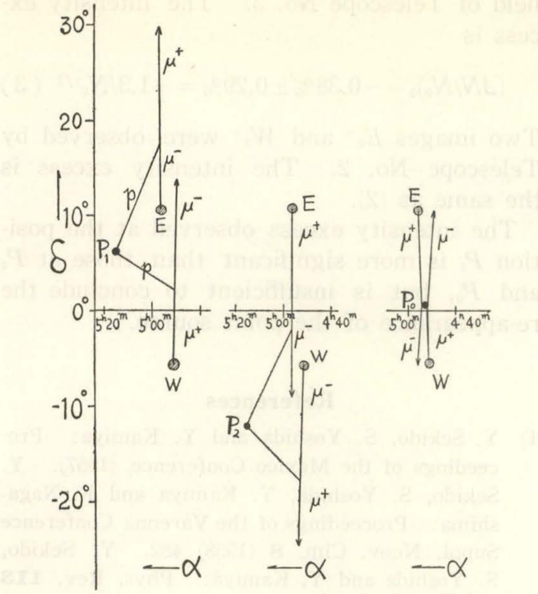

Fig. 10. Geomagnetic deflection of particles from the point source.

μ^+, μ^-, P: Geomagnetic deflections of μ^+-mesons, μ^--mesons and protons, respectively.

E_2, W_2: Images expected to be observed with Telescope No. 2.

E_3, W_3: Images expected to be observed with Telescope No. 3.

of Telescope No. 3 covered all of four images E_3^+, E_3^-, W_3^+ and W_3^-, the survival probabilities of mesons are 0.43 for E_3^- and W_3^+, while 0.34 for E_3^+ and W_3^-. As this difference is small, nearly equal intensity excess may be observed at these four images. So the observed intensities at these four expected positions were simply averaged in the course of making the intensity map. Similar procedure was applied to each of 52 different directions of primary protons to get the intensity map as shown in Fig. 11(a). The coordinate of the map is the direction of the primary protons before entering into the geomagnetic field. In this figure, the ex-

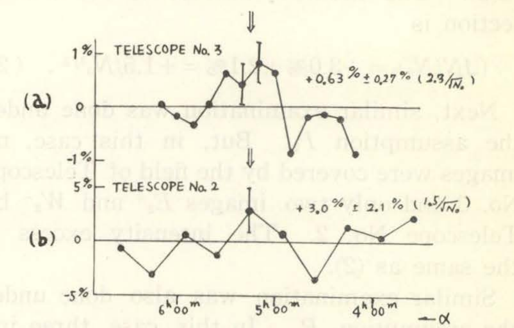

Fig. 11. Cosmic-ray intensity excess at $\delta=7°N$.

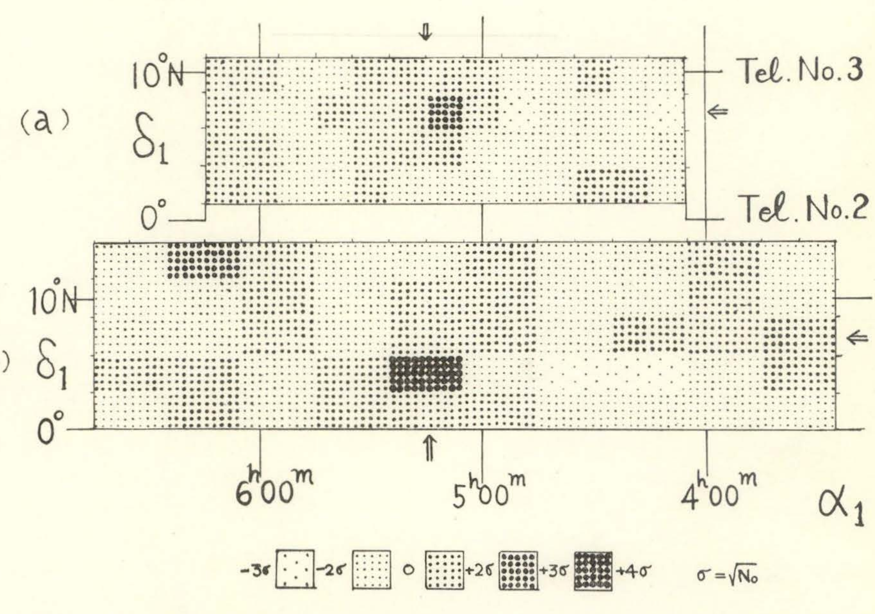

Fig. 12. Intensity map of primary protons before entering into the geomagnetic field. The position shown by ⇓ and ⇐ is the expected position P_1 of the point source.

(a): Observed with Telescope No. 3.

(b): Observed with Telescope No. 2.

pected position of the point source is $\alpha=5^h15^m$, $\delta=7.2°$. The intensities in the band including this declination is shown in Fig. 12(a). The intensity excess at the 20 min. section of the expected position is

$$(\Delta N/N_0)_3=+0.63\%\pm0.27\%=+2.35/N_0^{1/2}\,. \quad (1)$$

During the same period of observation (see Table III), the field of Telescope No. 2 covered only the two images E_2^- and W_2^+. The survival probabilities are 0.23 for both images. So considering these two images, similar procedure as the case of Telescope No. 3 was applied, thus obtaining the map of Fig. 11(b) and the intensity curve of Fig. 12(b). The intensity excess at the 20 min. section is

$$(\Delta N/N_0)_2=+3.0\%\pm2.1\%=+1.5/N_0^{1/2}\,. \quad (2)$$

Next, similar examination was done under the assumption P_2. But, in this case, no images were covered by the field of Telescope No. 3 and only two images E_2^+ and W_2^- by Telescope No. 2. The intensity excess is the same as (2).

Similar examination was also done under the assumption P_0. In this case, three images E_3^+, W_3^+ and W_3^- were covered by the field of Telescope No. 3. The intensity excess is

$$(\Delta N/N_0)_3=-0.38\%\pm0.29\%=-1.3/N_0^{1/2} \quad (3)$$

Two images E_2^+ and W_2^+ were observed by Telescope No. 2. The intensity excess is the same as (2).

The intensity excess observed at the position P_1 is more significant than those at P_2 and P_0, but is insufficient to conclude the re-appearance of the point source.

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