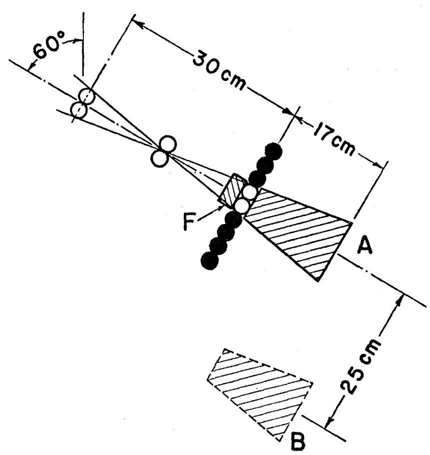

FIG. 1. Geiger counter telescope fixed at zenith angle of 60°. Lead can be placed at F and A and moved periodically from A to B.

scope. This was removed for a second flight. Both flights were carried by "Skyhook" plastic balloons and remained level at about 80,000 feet (27 g/cm²) for several hours. Data from the level portions are summarized in Table I.

If one compares the telescope counting rates to determine the upward flux subtracted out by the lead block, one finds no significant difference between the "A" and "B" rates in either experiment. The large lead block has a stopping power corresponding to 200-Mev μ-mesons or 400-Mev protons.

In interpreting the results one must consider that although the large block is capable of removing certain albedo particles generated in the atmosphere, it in turn generates an albedo effect proportional to the number of energetic nucleons or other interacting particles incident on the block from top and sides. If this albedo generation is detected as 4-fold events, the shower counter rate should increase monotonically to the top of the atmosphere. The observed 4-fold events, on the other hand, follow the telescope flux, and when the 3-fold counting rate passed a peak as the balloon passed through the region of the Pfotzer maximum for the telescope at 60° (without F), the shower rate also passed a maximum and then decreased.

The small lead block F contributes a large fraction of the shower events when present in the telescope, and in this case the Pfotzer maximum is not observed in either telescope or showers. The shower rate is considerably higher in position "A" than "B," and reaches 20 percent of the telescope rate. Despite the negative result of this experiment and the arguments given above, there is a chance that the true albedo effect is obscured by these showers. The apparatus, in principle, gives no information about the albedo effect for particles more energetic than a few hundred Mev. The balloon flights for the above experiments and those described in the following letter were made at Minneapolis.

* This work supported by the joint program of the AEC and ONR.
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Application of Čerenkov Radiation to the Cosmic-Ray Albedo Problem*

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THE Čerenkov light[1] from fast charged particles is emitted in a cone about the particle direction with the ray direction inclined to the particle direction at an angle θ given by $\cos\theta = 1/\beta n$, where n is the index of refraction of the medium. It has been shown both experimentally[2] and theoretically[3] that the angular dependence is a δ-function in θ for particles of equal β. The apparatus shown in Fig. 1 makes use of this behavior of the Čerenkov light to establish the direction of motion of a cosmic-ray particle. The Geiger counters form a telescope whose solid angle between the tubes is filled by the 15 cm long lucite block. Čerenkov light from downward particles is internally reflected and reaches the end-window photomultiplier (E.M.I. type 5311) which is optically sealed to a slant face of the lucite block. Light emitted by upward moving particles is internally reflected upwards and is absorbed by the black upper surface of the lucite. This absorbing surface is increased by slots as shown.

The behavior of the apparatus when detecting cosmic-ray particles is summarized in Table I. Pulse-height distributions for the

TABLE I. Čerenkov counting efficiency.

Bias		0	10	15	20	25	30
Sea level 0° zenith	n_1	0.94	0.90	0.86	0.80	0.62	0.33
	n_2	0.21	0.16	0.13	0.077	0.060	0.038
	n_2/n_1	0.23	0.18	0.15	0.098	0.096	0.12
120–150 g/cm² 0° zenith	n_1	0.70	0.66	0.64	0.60	0.54	0.43
	n_2	0.16	0.15	0.11	0.10	0.07	0.05
0° zenith	n_1	0.93	0.92	0.91	0.89	0.86	0.77
	n_2	0.18	0.16	0.13	0.11	0.09	0.07
17 g/cm² 60° zenith	n_1	0.69	0.66	0.62	0.57	0.44	0.25
	n_2	0.16	0.14	0.13	0.11	0.11	0.08
60° relativistic albedo at 17 g/cm²		0.03 ±0.02	0.03 ±0.02	0.04 ±0.02	0.05 ±0.02	0.06 ±0.02	0.07 ±0.02

photomultiplier pulses in coincidence with the counter telescope were obtained at sea level in a basement room under 4 feet of concrete, and at various atmospheric depths using balloon techniques. The tabular values give the ratio (Čerenkov-telescope counts)/(total telescope counts), for various relative bias values. n_1 refers to the apparatus oriented upwards as shown in the figure, and n_2 to the apparatus rotated 180° about axis A–A.

At sea level 94 percent of the cosmic-ray particles give detectable light pulses. The reverse efficiency n_2 for the same bias is 21 percent. With higher bias values the back-front ratio, n_2/n_1, decreases to a minimum of 10 percent, which approximately agrees with data obtained by Jelly[4] using a water cell. Part of the "back" efficiency can be explained by side showers, but the major part is the result of other causes which are being investigated.

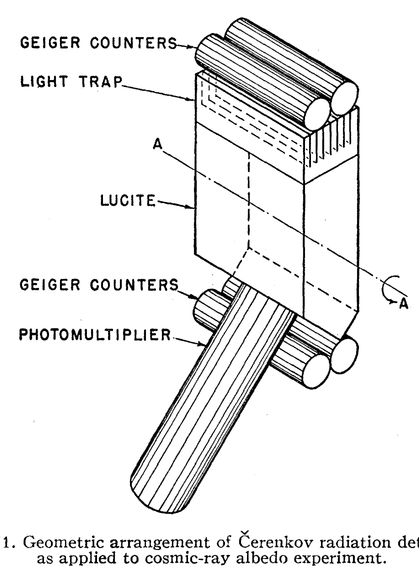

FIG. 1. Geometric arrangement of Čerenkov radiation detector as applied to cosmic-ray albedo experiment.

At 120–150 g/cm² atmospheric depth (about the depth of the Pfotzer maximum) the efficiency drops to 70 percent with bias "0." This is interpreted as being caused by particles of velocity below the Čerenkov threshold ($\beta=0.7$ for lucite) which trigger the telescope but do not give a detectable Čerenkov pulse. Analysis shows that these particles must be protons, as mesons or electrons having the 25 g/cm² range necessary to traverse the detector would be well above the threshold. Comparison with the sea-level data shows that between 24 percent and 30 percent of the particles at the Pfotzer maximum having a range of 25 g/cm² or greater must be these protons, of energy between 185 and 400 Mev. The absolute flux is 0.07 ± 0.01 particle cm^{-2} sec^{-1} sterad^{-1}.

At 17 g/cm² atmospheric depth the vertical efficiency is 93 percent, indicating that, as in the basement laboratory, all or nearly all particles are relativistic with β well above 0.7. At 60° zenith angle, however, the nonrelativistic or backward flux increases, and the efficiency drops to 69 percent. If one assumes that the relativistic vertical backward flux at sea level or at 17 g/cm² is negligible, then one can calculate the 60° zenith backward relativistic flux from the relation

$$\text{Albedo}=\frac{\text{relativistic up}}{\text{total down+up}}=\frac{n_2'n_1-n_1'n_2}{n_1^2-n_2^2},$$

where n_1' and n_2' are the observed Čerenkov efficiencies at 60° zenith angle, and n_1 and n_2 the efficiencies for the same bias at sea level. Calculated albedo values are given in the last line of the table. These data have poor statistical accuracy because of the subtraction process and insufficient data at high altitude.

The apparatus in principle gives no albedo data on nonrelativistic particles, and in its present crude form, requires two measurements differing by 180° in zenith to determine the backward flux. It appears, however, that with further development this type of detector will have a number of applications in cosmic-ray research.

Acknowledgment is made to C. L. Critchfield for the initial suggestion of applying Čerenkov radiation to this problem, and to Mr. Baskin and Mr. Mitchell for valuable assistance with the experiment.

* This work supported by the joint program of the AEC and ONR.
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A Second γ-Transition ($d_{\frac{3}{2}}\rightarrow s_{\frac{1}{2}}$) in Xe^{129m}

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EARLIER we have reported a new isomer of Xe^{129}.[1] It was found that the ratio of the intensities of the K and L conversion electrons of Xe^{129m} was close to that of Xe^{131m}, indicating

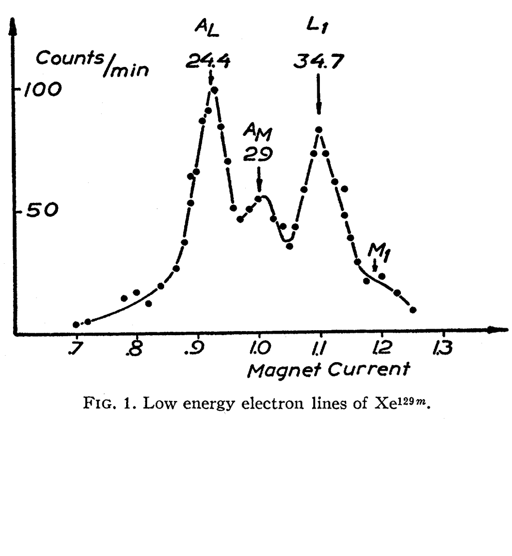

FIG. 1. Low energy electron lines of Xe^{129m}.

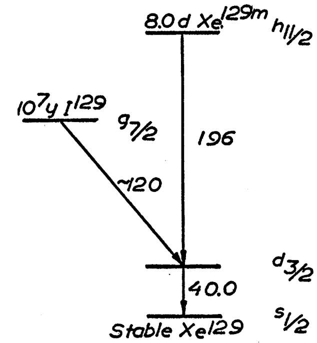

FIG. 2. Decay scheme of I^{129} and Xe^{129m}.

that the isomeric transitions are of the same type. The spins of the ground states of Xe^{129} and Xe^{131} are known to be 1/2 and 3/2 respectively. The experiments then favored the spins 9/2 and 11/2 for the isomeric states. However, the strong spin-orbit coupling model suggests the spin 11/2 also for the isomeric state of Xe^{129}. In order to obtain agreement with the theory, it is necessary to postulate a second γ-ray in the decay of Xe^{129m}. We have remeasured Xe^{129m} with a stronger sample and found a γ-ray of the energy 40.0 kev.

Figure 1 shows the low energy electron lines of an electromagnetically separated Xe^{129m} sample. In addition to the K and $L+M$ conversion lines of the 196-kev isomeric γ-ray and the two strongest Auger lines, there is a line at the energy 34.7 kev, which for the following reason must be interpreted as the L line of a 40.0-kev γ-ray. Earlier experiments[2] on Xe^{131m} have shown that the intensity ratio of the Auger lines and the isomeric K conversion line is 0.16 ± 0.02 (fluorescence yield of $\text{Xe}=0.84\pm0.02$). From Fig. 1, however, we find that this ratio is about twice the expected value. This means that Auger electrons must also be due to another K conversion line, having an intensity comparable to that of the K line (K_2) of the isomeric γ-ray. The intensity of the 34.7-kev line, however, is only $\sim$0.15 of that of the K_2 line. It must therefore be concluded that the 34.7-kev line is an L line of a γ-ray of the energy 40.0 kev. The corresponding K line at 5.4 kev cannot be detected with the GM-window, which we used.

Borkowski and Brosi[3] have reported a 39-kev γ-ray in the decay of I^{129}. This γ-ray is certainly identical with that found by us. The decay scheme of Xe^{129m} and I^{129} is presented in Fig. 2. Thus Xe^{129m} is now in excellent agreement with the predictions of the strong spin-orbit coupling model.

It should be pointed out that we have not been able to observe the crossover transition. $E5$ radiation is thus in this case much less probable than $M4$ radiation, which is in contradiction to older theories. Hill[4] has reached similar conclusions for some of the Te isomers.

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Probing the Space-Charge Layer in a *p-n* Junction

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ACCORDING to theory, the rectifying junctions of semiconductor art involve space-charge layers. These layers contain relatively small densities of holes and electrons and acquire their charge density from ions, donors, and acceptors. Evidence for the presence of these layers has been obtained from capacity measurements of rectifying diodes biased in the reverse