

pletes essentially the investigations begun in 1948 for the purpose of studying the latitude effect of primary nuclei of charge $Z > 1$. The flux values obtained in two separate flights near the magnetic equator agree well within statistical accuracy and are given by $I(\lambda = 3^\circ) = 1.30 \pm 0.25$ particles/m² sec steradian for $6 \leq Z \leq 10$, and $I(\lambda = 3^\circ) = 0.30 \pm 0.07$ particles/m² sec steradian for $Z > 10$.

Previously² it has been shown that all primaries arrive from outer space completely stripped of orbital electrons and that, therefore, the flux values at different latitudes permit the construction of an integral energy spectrum for the various components. The flux values obtained at the equator are in good agreement with the energy spectrum given in reference 2.

Our knowledge of the spectrum in the energy region above geomagnetic cut-off energies is less complete both for the proton and the heavy components. However, the results of various recent investigations permit us to describe quite reliably the charge and energy dependence of primary particles up to about one hundred times the equatorial cut-off energy.

On the basis of Fermi's theory of meson production and the range spectrum of mesons below ground, Haber-Schaim³ deduces an integral spectrum proportional to $\epsilon^{-1.56}$ for the total primary radiation in the energy interval $10^{11} < \epsilon < 1.2 \times 10^{12}$ ev (ϵ is the energy per nucleon).

Independent support for this power law is obtained from the photographic emulsion technique applied to Auger showers.⁴ Preliminary results⁵ obtained with this technique indicate that the flux, not only of protons but also of primary helium nuclei, is in the energy interval $10^{10} < \epsilon < 4 \times 10^{12}$ ev consistent with the power law exponent derived from observations on mesons.

Also heavy nuclei of charge $Z > 10$ seem to follow the same power spectrum. This was verified up to energies of 5×10^{10} ev/per nucleon with the help of nuclear collisions.² Occasional observations on nuclei of still larger energies, however, make it certain that no drastic change in the exponent occurs up to about 5×10^{11} ev/nucleon.

Thus we are led to the conclusion that the chemical composition of the primary beam is essentially constant not only in the latitude sensitive region but even at much higher energies. The uniformity of composition holds at least over a factor 1000 in the energy per nucleon, a range of energies which comprises all but one part in ten thousand of the incoming primaries and at least 95 percent of the incident energy.

The incident cosmic-ray energy carried by various primary components is approximately distributed as follows:

- 66 percent due to protons;
- 26 percent due to helium nuclei;
- 5 percent due to carbon, nitrogen, and oxygen;
- 3 percent due to nuclei of atomic number $Z \geq 10$.

It is important to note that this distribution, which has previously been obtained⁶ for a much more restricted range of energies, has now been shown to be valid for the primaries which produce the bulk of cosmic radiation at sea level ($5 \times 10^9 < \epsilon < 5 \times 10^{11}$ ev/nucleon) and therefore represents also the relative contribution of different components to the sea level intensity. Thus, since the sea level intensity if corrected for barometric and temperature effects shows a variation with solar time of only about 0.3 percent and a variation with sidereal time of less than 0.02 percent,⁷ it follows that even for the heaviest primary nuclei in this energy range the variation with solar time must be less than 10 percent and with sidereal time less than 1 percent.

¹ A full description of these experiments, which were carried out jointly by the Tata Institute of Fundamental Research and the University of Rochester will be published elsewhere.

² Kaplon, Peters, Reynolds, and Ritson, *Phys. Rev.* **85**, 295 (1952).

³ U. Haber-Schaim, *Phys. Rev.* **84**, 1199 (1951).

⁴ Kaplon, Peters, and Ritson, *Phys. Rev.* **85**, 900 (1952).

⁵ Kaplon, Ritson, and Woodruff, *Phys. Rev.* **85**, 933 (1952).

⁶ B. Peters, *The Nature of Primary Cosmic Radiation* (North-Holland Publishing Company, 1952), Chapter IV, "Progress in Cosmic Ray Physics."

⁷ H. Elliot, see reference 6, Chapter VIII.

Internal Conversion of the 0.411-Mev Gamma-Ray of Hg¹⁹⁸

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(Received March 25, 1952)

ON the basis of the measured spectra of the beta- and gamma-rays of Au¹⁹⁸¹ the *K*, *L*, and *M* conversion coefficients of the 0.441-Mev gamma-ray were found with an accuracy better than one percent to be $\alpha_K = 0.0318$; $\alpha_L = 0.0103$; $\alpha_M = 0.0031$. The values were obtained on the supposition of a one-to-one occurrence of a 0.965-Mev electron and a 0.411-Mev gamma-quantum. On the other hand, if one assumes according to Cavanagh² that in addition to the 0.965-Mev beta-ray the 0.29-Mev beta-ray (branching ratio 1.76 percent) is followed in part by the 0.411-Mev gamma-ray after a 0.67-Mev gamma-emission (branching ratio 1.43 percent), one obtains for the 0.411-Mev gamma-ray $\alpha_K = 0.0307$. The vanishing intensity of the 1.37-Mev beta-ray has been neglected and the branching ratio of the *K*-capture transition to Pt¹⁹⁸ has been estimated to be approximately five percent. Considering the accuracy of the measurements, this latter value of the *K* conversion coefficient for the 0.411-Mev gamma-ray of Hg¹⁹⁸ agrees exceptionally well with the theoretical value, $\alpha_K = 0.031$, obtained by interpolation of the coefficients calculated by Rose *et al.*³ for electric quadrupole radiation. An agreement between theory and experiment has thus been established and one may unambiguously conclude that the 0.411 gamma-ray of Hg¹⁹⁸ is a pure electric quadrupole radiation.

¹ L. Simons and E. P. Tomlinson, *Soc. Sci. Fenn. Comm. Phys. Math.* XVI, 6 (1952).

² P. E. Cavanagh, *Phys. Rev.* **82**, 791 (1951).

³ Rose, Goertzel, Spinrad, Harr, and Strong, *Phys. Rev.* **83**, 79 (1951).

Thermal Conductivity of Germanium

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(Received March 21, 1952)

A MEASUREMENT has been made of the thermal conductivity of high purity, single-crystal germanium, made by the method of Teal and Little.¹ Conductivity was determined from the relative temperature drops along rods of germanium and some material of known conductivity, placed thermally in series. Nickel and cast zinc of high purity were used for the comparison materials. With precautions taken to minimize errors from heat losses, it is believed the measurements are accurate to better than ± 10 percent.

The germanium specimen was cut from a single crystal of *n*-type material of resistivity about ten ohm-cm. Its dimensions were 5/16 inch square cross section by 3/4 inch long, with the long dimension oriented along a 100 crystal axis. The thermal conductivity was found to be 0.14 cal/sec cm °C at 25°C, and roughly 20 percent less at 100°C.

¹ G. K. Teal and J. B. Little, *Phys. Rev.* **78**, 647 (1950).

Short Duration Afterglow of Nitrogen in the Photographic Infrared

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(Received March 31, 1952)

KAPLAN¹ was the first to study the afterglow of long duration (0.1 to 1 sec) which produces the first negative band system, $B^2\Sigma - X^2\Sigma$, of N₂⁺. A short duration afterglow (10⁻⁴ to 10⁻² sec) emitting the same band system has been described by us elsewhere.² The present note is concerned with an extension of