illustrated by helium p_2n_2 *whose cosmic abundance, according to the latest estimate, is 120 times greater than that of **all** of the other elements*, excluding hydrogen, which has a simple nucleus. This shell of 2 neutrons or of 2 protons has not received the attention which it merits.

For a discussion of closed shells with 20, 50, 82 neutrons or protons, or 126 neutrons, a paper by Maria Mayer may be consulted.[2]

[1] W. D. Harkins and M. Popelka, Jr., Phys. Rev. **76**, 989 (1949).
[2] M. G. Mayer, Phys. Rev. **74**, 235 (1948).

The Ratio of L_I to K Capture*

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September 29, 1949

THE phenomenon of orbital electron capture from the L_I shell was observed recently by Pontecorvo, Kirkwood, and Hanna[1] in A^{37}. The experimental value of the ratio of probabilities for L_I to K capture was reported to be between 8 and 9 percent. As was mentioned in reference 1 a computed ratio of only 6 percent is obtained using relativistic wave functions with Slater screening constants.[2]

It is possible to use a much better representation of the screening and we have calculated the L_I to K capture ratio using (1) relativistic wave functions computed on the Eniac by J. Reitz[3] with a potential function obtained from a Thomas-Fermi field with exchange and (2) self-consistent field wave functions.[4] In the case of the relativistic wave functions the small screening for the 1*s* wave function was not considered and an extrapolation had to be carried out since the 2*s* wave functions are available for $Z=29$, 49, 84 and 92 only. Since the ratio is not very sensitive with Z (see Fig. 1), this extrapolation seems safe enough. The Hartree wave functions used for A included the effect of exchange and the neglect of non-relativistic effects makes a rather trivial error in the case of A. The results are:

	L/K ratio
(1) relativistic wave functions	8.2 percent
(2) Hartree wave functions	8.1 percent

and the agreement with the observed value is all that could be desired.

The L/K ratio for other values of Z may be obtained from Fig. 1, curve (1) for medium and heavy atoms and curve (2) for light atoms. In Fig. 1 the square of the ratio of the 2*s* to 1*s* wave functions at the nuclear radius is shown. The L/K capture ratio is obtained by multiplying by the square of the ratio of neutrino energies in the two cases,[2] but in almost every case this latter ratio should be very close to unity.

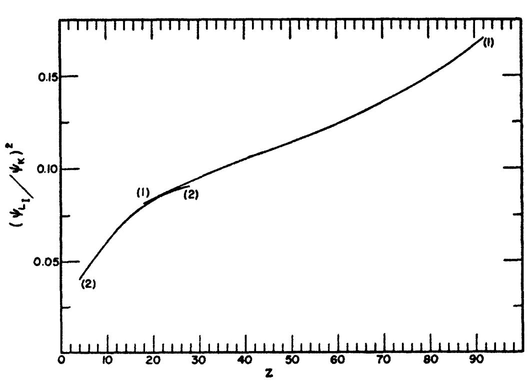

FIG. 1. Ratio of electron densities for L_I and K shell at nuclear radius *versus Z*: Curve (1): relativistic wave functions with Thomas-Fermi field plus exchange. Curve (2): Hartree self-consistent field wave functions. To obtain ratio of L_I to K capture multiply by square of ratio of neutrino energies in the two cases, $(E_{L_I}/E_K)^2$.

* This document is based on work performed under Contract No. W-7405, eng 26 for the AEC at the Oak Ridge National Laboratory.
** Present address, New York University.
[1] Pontecorvo, Kirkwood, and Hanna, Phys. Rev. **75**, 982 (1949).
[2] R. E. Marshak, Phys. Rev. **61**, 431 (1942).
[3] The authors are indebted to Dr. Reitz for a pre-publication copy of these wave function tables.
[4] Complete references are to be found in D. R. Hartree, Reports on Progress in Physics, XI (1946–47).

The Disintegration Scheme of Tm^{170}

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September 27, 1949

NEW evidence for the complexity of the beta-ray spectrum of 127-day Tm^{170} has been obtained by the use of a thin lens spectrometer supplemented by β-γ-coincidence measurements. The beta-ray spectrum has been shown to consist of two components; one with a maximum energy of (970 ± 5) kev as reported previously, and a second with an endpoint of (886 ± 5) kev comprising approximately 10 percent of the transitions. The single weak gamma-ray,[1–4] largely internally converted, has been found to have an energy of (83.9 ± 0.2) kev.

The source was prepared from "Specpure" Tm_2O_3 irradiated in the Chalk River pile to give a specific activity of 5 mc/mg. The source thickness was estimated to be 0.25 mg/cm² and it was mounted on a 0.03 mg/cm² Nylon film rendered conducting by a layer of evaporated aluminum (0.02 mg/cm²). The counter window was made up of Nylon films to a thickness of 0.055 mg/cm² and passed electrons of energy greater than 7 kev. Good statistics were obtained and the high energy end of the spectrum was studied carefully. The Kurie plot of the beta-spectrum using the relativistic coulomb correction factor is shown in Fig. 1. If the assumption is made that the higher energy group is of the allowed shape, then the discontinuity in the Kurie plot is indicative of a weak beta-ray group of lower maximum energy. Subtraction of the main group from the total yields a reasonably straight line which when extrapolated to the energy axis gives an end point of (900 ± 20) kev (curve *C*, Fig. 1). The rise of the curve

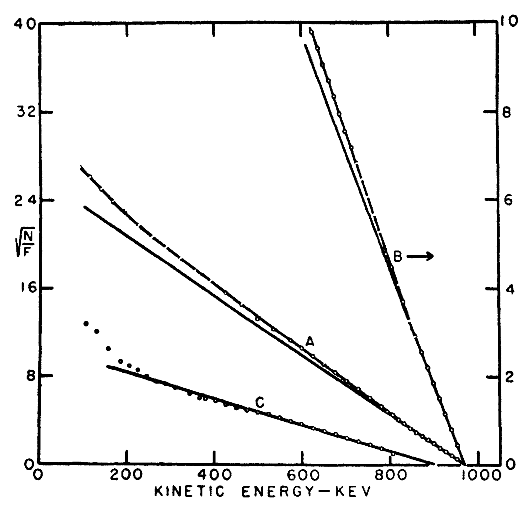

FIG. 1. Kurie plot of the Tm^{170} beta-spectrum. Curve *A* is the curve of the experimental points, curve *B* is the high energy end plotted with an expanded ordinate scale, and curve *C* is obtained by subtracting the main group.

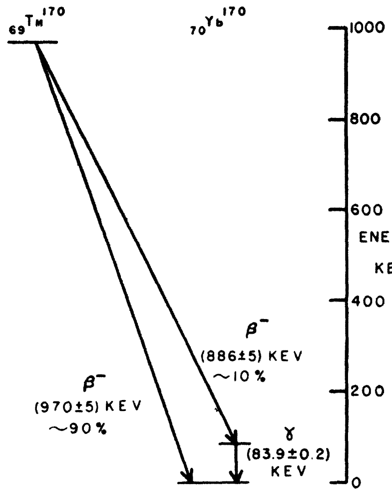

FIG. 2. Tentative decay scheme for Tm^{170}.

above the straight line at energies less than 240 kev is assumed to be due to scattering within the source.

A second source of 0.1 mg/cm² on a 0.5 mg/cm² aluminum backing was used to check the efficacy of the method of grounding the first source. The locations of the conversion lines and the end point agreed, within the accuracy of calibration, with those obtained with the first source. The effects of scattering in the source were slightly decreased in the thinner source.

The energy of the gamma-ray was computed from the K, L, and M conversion lines on the beta-spectrum at 22.6, 73.5, and 81.2 kev respectively as well as from the L and M photo-electron lines using a 15.3 mg/cm² lead radiator. A search for other gamma-rays[4] using a 40-mc source with lead and uranium radiators yielded a negative result.

The significant result obtained from the coincidence experiments was the very low ratio of beta-gamma-coincidences to beta-rays. A brass-cathode gamma-counter and a 2.1 mg/cm² mica end-window beta-counter were used in conjunction with a coincidence mixer of 0.45-microsecond resolving time. An aluminum absorber, 16 mg/cm², was placed before the beta-counter to avoid registering coincidences between conversion electrons and x-rays.

For the simple decay scheme previously proposed,[2,3] the ratio of the beta-gamma-coincidence rate, $N_{\beta\gamma}$, to the beta-counting rate should be equal to ϵ_γ, the efficiency of the gamma-counter in the experimental geometry. For the decay scheme depicted in Fig. 2 this ratio will be $N_2(1-\alpha)/(N_1+N_2)\epsilon_\gamma$, where N_1 refers to beta-particles in the group going to the ground state, N_2 to the lower energy group and α is the ratio of converted gamma-rays to N_2. The value of ϵ_γ for 84-kev gamma-rays was measured by calibrating the coincidence apparatus with Co^{60} gamma-rays and by referring to a semi-empirical efficiency curve for a similar counter.[5] The result was $\epsilon_\gamma=(2.9\pm0.2)\times10^{-4}$. The average of the two experimental values obtained for the ratio $N_{\beta\gamma}/N_\beta$ is $(3.05\pm1.0)\times10^{-6}$. The inference is that the factor $N_2(1-\alpha)/(N_1+N_2)$ is of the order 0.01. The Kurie plot analysis of the beta-spectrum leads to a value of approximately 0.1 for the ratio $N_2/(N_1+N_2)$. Thus $\alpha\cong0.9$.

The conversion coefficients were also measured from the ratios of the height of the lines above the continuum to the area corresponding to the group N_2. The line heights were corrected approximately for window absorption after a method described by Witcher,[6] using Nylon absorbers before the counter window. The results are $\alpha_K=0.08$, $\alpha_L=0.55$, and $\alpha_M=0.17$ so that $\alpha=0.80$.

The low beta-gamma-coincidence rate obtained here is in fair agreement with that obtained by Ketelle[7] who states that the gamma rays are in coincidence with not more than 10 percent of the beta-rays.

The result would be consistent with the simple decay scheme only if the gamma-ray were converted more than 90 percent whereas the experimental value would be about 8 percent referred to the simple scheme. A decay scheme which is consistent with all of the present results is given in Fig. 2.

The resolving power of the coincidence-absorption method used by Graham and Tomlin[3] is probably too low to distinguish between the two proposed decay schemes.

The author wishes to express his appreciotion to Professor J. S. Foster, for his help and advice throughout this work and to Dr. D. G. Douglas for valuable discussions and assistance.

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[4] P. J. Grant and R. Richmond, Nature **163**, 840 (1949).
[5] G. F. von Droste, Zeits. f. Physik **100**, 529 (1936).
[6] C. M. Witcher, Phys. Rev. **61**, 32 (1941).
[7] B. H. Ketelle (private communication to the author).

Erratum: Altitude Dependence of Penetrating Particles Slowed Down After Traversing 15 Cm of Lead

[Phys. Rev. **76**, 851 (1949)]

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THE numbers per hour of mesons (M) and of X-particles (X) stopped in the absorber must be multiplied by the factor 1.6×10^{-7} (not 1.1×10^{-7} as stated in the paper) in order to obtain the corresponding absolute numbers per sec., g, sterad. The ordinate of Fig. 1 must be multiplied, accordingly, by (1.6/1.1).

The "true anticoincidences" at 30,000 feet, in the fourth line of Table I, are 925±30 per hour (not 985±30).

Magnetic Multipole Internal Conversion

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September 30, 1949

IN a previous letter[1] on the calculation of magnetic internal conversion coefficients in the Pauli approximation curves of the ratio of the coefficients in the K shell to those in the L shell

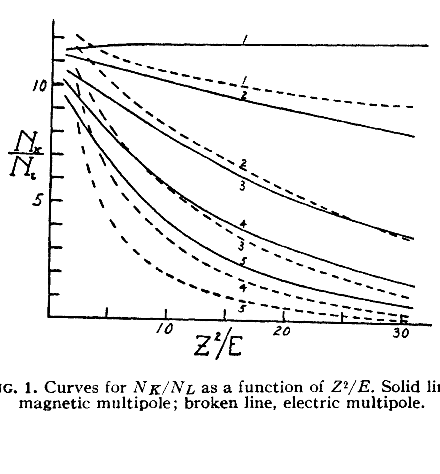

FIG. 1. Curves for N_K/N_L as a function of Z^2/E. Solid line, magnetic multipole; broken line, electric multipole.