secondary electron spectrum produced by the γ-rays in a thin lead converter shows three nuclear gamma-rays of energies 0.477 Mev, 0.935 Mev, and 1.41 Mev. By comparing the number of photoelectrons due to these with those due to the annihilation radiation, we estimate the abundances of these three gamma-rays (in order of increasing energy) to be 0.3, 1.4, and 0.3 per positron. The negative electron spectrum consists of four internal conversion lines. Three of these correspond to the above gamma-rays and the intensities of the lines are about 7.4×10^{-4}, 5.4×10^{-4}, and 3.5×10^{-5} conversion electron per positron, in order of increasing energy. In addition, a conversion line was found corresponding to a 0.095-Mev γ-ray. The intensity of this line is about 1×10^{-3} electron per positron. Coincidences between gamma-rays and positrons of definite energies (selected in a magnetic-lens spectrometer designed for coincidence experiments[3]) were measured using copper-walled and gold-walled G-M counters. The combined results of the experiments lead us to conclude that the main decay scheme of Co^{55} is as shown in Fig. 1. The two positron

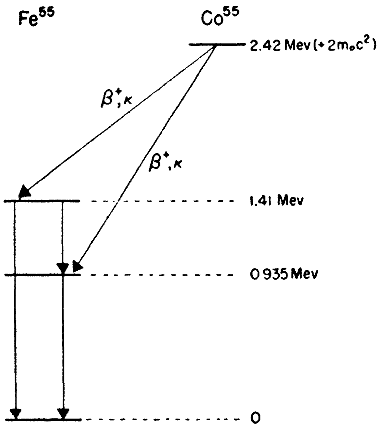

FIG. 1. Decay scheme of Co^{55}.

transitions are of approximately equal intensity. The same is true for the 0.477-Mev and 1.41-Mev gamma-rays. If our estimate of the intensities of the several gamma-rays compared with the number of positrons is correct, orbital electron capture is considerably more probable than expected theoretically for allowed transitions, particularly in the case of the transition to the 0.935-Mev level. The significance of the 0.095-Mev gamma-ray is not yet understood, but its intensity must be quite low. A more complete report on these experiments will be submitted for publication in the Arkiv for Matematik Astronomi och Fysik.

We wish to express our gratitude to Professor Manne Siegbahn and the Swedish Academy of Science for the generous hospitality extended to one of us (M.D.), and to the staff of the Nobel Institute for their friendly cooperation.

* On leave from Massachusetts Institute of Technology, Cambridge, Massachusetts.
[1] Siegnahn, Svartholm, and Hedgran (to be published).
[2] J. L. Lawson, Phys. Rev. **56**, 131 (1939).
[3] K. Siegbahn and A. Johanson, Arkiv f. Mat. Astr. Fys., **34A**, No. 10 (1946).

Electron-Neutrino Correlation in Heavy Elements*

M. E. ROSE
Oak Ridge National Laboratory, Oak Ridge, Tennessee
March 14, 1949

THE electron-neutrino correlation for both allowed and first forbidden transitions has been discussed by Hamilton.[1] For allowed transitions the correlation function is

$$F(\theta)=1+n\beta\cos\theta, \quad (1)$$

where θ is the angle between electron and neutrino directions, $\beta=v/c$ and $n=-1$ for scalar and pseudoscalar, $\frac{1}{3}$ for tensor $(G-T)$, $-\frac{1}{3}$ for axial vector and 1 for polar vector (Fermi) interactions. Since (1) assumes plane wave electrons $(Z=0)$ it is of interest to consider the effect of the Coulomb field[2] in order to determine whether or not the consequent change in the factor n may be as large as a factor 3. In the following we consider only allowed transitions.

For this purpose the following approximative calculation has been performed. A Dirac plane wave corresponding to a z-component of spin equal to $\frac{1}{2}$ can be expanded in terms of a representation in which j^2 and j_z, where j is the total angular momentum, are diagonal. This gives

$$\psi_{\frac{1}{2}}^{(0)}(\theta,\phi)=\text{const.}\sum_{l,m} i^l(2l+1)^{-\frac{1}{2}}Y_l^{m*}(\theta,\phi)\times[(l-m)^{\frac{1}{2}}u_{lm}^{(-)}-(l+m+1)^{\frac{1}{2}}u_{lm}^{(+)}], \quad (2)$$

where θ, ϕ are the polar and azimuth angles of the direction of motion of the electron, Y_l^m a normalized spherical harmonic and $u^{(\pm)}$ are spherical free particle wave functions for $j=l\pm\frac{1}{2}$. The superscript (0) indicates $Z=0$. For z-component of spin equal to $-\frac{1}{2}$ the corresponding expansion can be obtained from (2) by applying the usual operator which converts $\psi_{\frac{1}{2}}^{(0)}$ to $\psi_{-\frac{1}{2}}^{(0)}$. Of course, in (2) we can set $\theta=0$ and therefore $m=0$. We now use the same unitary transformation for the Coulomb field. That is, the wave functions used for the electron are given by (2) with $u_{lm}^{(\pm)}$ identified with solutions for the Dirac Coulomb field in the representation j^2, j_z diagonal. This approximation can be justified if the effect of the Coulomb field is small.

For allowed transitions we need only the terms $j=\frac{1}{2}$, $l=0$, 1 corresponding to $s_{\frac{1}{2}}$ and $p_{\frac{1}{2}}$ electrons. The correlation function then has the form (1) with n replaced by nf where f, which is independent of the type of interaction, is given by

$$f=\tfrac{1}{3}[1+2(1-\alpha^2Z^2)^{\frac{1}{2}}](1+\alpha^2Z^2/p^2)^{\frac{1}{2}}. \quad (3)$$

In (3) α is the fine structure constant and p is the electron momentum in units mc. Averaging (3) over a typical energy distribution for allowed transitions we find that even for an element as heavy as Pb, the value of $\langle\beta f\rangle_{Av}$ differs from $\langle\beta\rangle_{Av}$ by about 20 percent. Therefore one may safely disregard effects of the Coulomb field in comparing theory and experiment for the purpose of distinguishing between the various forms of the beta-interaction.

* This document is based on work performed under Contract No. W-7405-eng-26 for the AEC at the Oak Ridge National Laboratory.
[1] D. R. Hamilton, Phys. Rev. **71**, 456 (1947).
[2] Obviously, no significant effect from the Coulomb field would be expected in an experiment like that of J. S. Allen *et al.*, Phys. Rev. **75**, 570 (1949), in which He^6 was used. However, the question of the Coulomb field might arise in the case of Y^{90} used in the measurements of C. W. Sherwin, Phys. Rev. **73**, 1173 (1948).

A Possible Experimental Verification of the Statistics of He^3

D. TER HAAR
Department of Physics, Purdue University, Lafayette, Indiana
March 18, 1949

IN principle it is possible to determine whether He^4 obeys Fermi-Dirac or Bose-Einstein statistics by measuring the second virial coefficient B. J. de Boer,[1] and Massey and Buckingham[2] have calculated B starting from a field of force determined by measurements at high temperatures. It turns out that the $BT^{\frac{1}{2}}$ curve (T: temperature) as a function of temperature shows a maximum at about 0.8°K if He^4 obeys Bose-Einstein statistics but that there is no such maximum if He^4 should obey Fermi-Dirac statistics. A difference between