nucleus has the same spin state in both cases. Thus the data may be an indication that $\Gamma_{\gamma r}$ is not constant but varies in a statistical manner, possibly as proposed by Porter and Thomas.  

An extensive program is underway to study several nuclides. It is hoped that spins and lifetimes can be assigned to the low-lying levels and that additional information can be obtained regarding the actual distribution of $\Gamma_{\gamma r}$.

†Work performed under the auspices of the U. S. Atomic Energy Commission.

1 Harvey, Hughes, Carter, and Pilcher, Phys. Rev. 99, 10 (1956).


4 Fenstermacher, Draper, and Bockelman (to be published).

5 Bollinger, Dahlberg, Palmer, and Thomas, Phys. Rev. 100, 126 (1955).


**Higher-Order Effects in the Allowed Beta Decay of $^{80}$**

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It has been proposed by Gell-Mann that the usual vector interaction in beta decay should be modified by addition of a small correction term due to the effect of virtual meson currents around the nucleons. This term is proportional to the difference of the anomalous magnetic moments of protons and neutrons and is of the order of $0.1\%$ per Mev beta energy. This correction term, if it exists, gives rise to a slight deviation from the well known allowed shape of the beta spectrum. An experiment to study this effect has been suggested.†

We consider here another way of studying this effect, namely the beta-gamma angular correlation. Normally the beta-gamma angular correlation of an allowed transition is isotropic. The
addition of the new term, however, gives rise to a small anisotropy which can be detected experimentally.

Since the resulting correction to both the beta spectrum and the beta-gamma angular correlation is very small, similar corrections due to the finite wavelength of the electron and relativistic nucleon motion have to be considered in both types of experiments. All these corrections are approximately of the same order of magnitude. Nevertheless, for a rough discussion we shall neglect these terms. Such an approximation is entirely equivalent to a description of a magnetic dipole transition by the anomalous magnetic moments of the nucleons alone, neglecting the orbital parts. Under this assumption one obtains for the angular distribution in the case of an allowed Gamow-Teller transition

$$W(\theta) = 1 - \frac{1}{3} \frac{\mu_p^2 - \mu_n^2}{2MC^2} \left( E_0 - E \left( 1 + \frac{v^2}{c^2} \right) \right)$$

$$+ \frac{\Sigma_{\lambda \lambda'} F_2 (\lambda, \lambda', I_f I_f') \delta_{\lambda \lambda'} \delta_{\lambda \lambda'}}{\Sigma_{\lambda} |\delta_{\lambda}|^2}$$

$$\times F_2 (1, 1, I_f I_f) 2 \frac{\mu_p^2 - \mu_n^2}{2MC^2} \frac{v^2}{c^2} E (\cos^2 \theta - \frac{1}{3}). \tag{1}$$

In this expression $\theta$ is the angle between electron and gamma quantum, $\mu_p - \mu_n = 3.7$, and all other quantities have conventional meaning such as defined in by Alder et al.\textsuperscript{2}

An experimental study of the coefficient of $\cos^2 \theta$ has been done for the beta decay of $F^{20}$. $F^{20}$ has an electron spectrum with an end point of 5.4 Mev and a subsequent gamma ray of 1.63 Mev. With a spin pattern $I_f = 2^+, I_f = 2^+$, $I_{ff} = 0^+$, Eq. (1) gives an angular distribution

$$W(\theta) = 1 + a \cos^2 \theta, \tag{2}$$

with

$$a = 1.0 \times 10^{-5} E \left( 1 - (m_e / E)^2 \right) (E, m_e \text{ in Mev}).$$

$F^{20}$ was produced by bombarding a CaF target with deuterons of 1.7 Mev from the 2-Mev Van de Graaf. The CaF target, which was prepared by vacuum vaporization onto a thin nickel foil, had a total thickness of a few hundred kilovolt for the incoming deuterons. Its thickness for electrons consequently was negligible. The target chamber consisted of a hollow Lucite cylinder of 3 inches inner diameter and 1 inch wall thickness. The deuteron beam entered the target chamber after passing through an electrostatic analyzer and impinging on a well-defined spot on the target.

The counter arrangement consisted of a 1 $\times$ 1 1/4-inch NaI crystal for the detection of the gamma rays and a 1 $\times$ 1 1/4-inch plastic scintillator for the detection of the electrons. The gamma counter was stationary and the beta counter was movable and could assume angles of 90° and 180° with respect to the gamma counter. Both counters were connected to a fast coincidence circuit.

The single pulses of the gamma counter were biased at 1.2 Mev and those of the beta counter at 4.5 Mev. These pulses together with the fast coincidence pulses were fed to a slow triple coincidence circuit. The ratio of accidental to real coincidences over one run was 5%. Data was taken in the following way. With the counters turned off the target was irradiated until a certain activity level of $F^{20}$ was reached as indicated by the monitor. The deuteron beam then was turned off and after a few seconds, when the source strength had assumed a certain preset value, the counters were turned on by the monitor system for a counting period of 16 seconds. About 300 coincidences were obtained in each run. Sets of 5 runs were taken at 90° and 180° alternatively. In the analysis, the number of triple coincidences was divided by the number of single counts in the beta counter, thus eliminating a possible small difference in the solid angle of the beta counter at 90° and 180°.

The result of this experiment, accepting all electrons above 4.5 Mev, is

$$a = (+0.94 \pm 0.28) \%.$$

This result has to be compared with the value of $a \approx +0.45\%$ derived from Eq. (2).

As a check of the experimental arrangement the beta-gamma angular correlation in the decay of Na$^{24}$ has been measured for an electron energy of 0.8 Mev. The value of $a = (+0.01 \pm 0.1)\%$ has been found. The theoretically predicted value from Eq. (1) is $a = +0.05\%$.

The observed effect in $F^{20}$ is the first indication of the presence of higher-order corrections in an allowed beta-gamma correlation experiment. The sign and the magnitude agree with the rough estimate of the Gell-Mann term.

Thanks are due to Professor M. Gell-Mann for many valuable discussions. One of us (V.S.) is indebted to the Kultusministerium of Baden-Württemberg, Germany, for a grant.

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\(^{1}\)Supported in part by the joint program of the Office of Naval Research and the U. S. Atomic Energy Commission.

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\(^{1}\)M. Gell–Mann, Phys. Rev. (to be published).

\(^{2}\)Alder, Stech, and Winther, Phys. Rev. 107, 728 (1957).

\(^{3}\)The spin \(2^+\) for the ground state of \(F^{20}\) seems more likely than the spin \(1^+\) reported by F. Ajzenberg and T. Lauritsen, Revs. Modern Phys. 27, 77 (1955). A spin assignment \(1^-\) would reverse the sign of \(a\).

\(^{4}\)In the case of a 2–2 transition we also would expect a contribution from the usual vector part. But this contribution must be small by virtue of the isotopic spin conservation. The "orbital parts" are consistently neglected [see Eq. (1) and above].

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ERRATUM


In the line following the first equation, the expression \(P_{18}(k)\) should be replaced by \(p_{18}(k)\).