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Experimental Beta-Gamma-Angular Correlation

RICHARD L. GARWIN*
Department of Physics and Institute for Nuclear Studies, University of Chicago, Chicago, Illinois

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THE number of gamma-rays emitted by a nucleus into unit solid angle has been measured as a function of angle with the preceding coincident beta-ray. Scintillation counters were used, the gamma-sensitive counter consisting of a 1-cm thick clear anthracene crystal subtending 0.13 steradian at the source. The beta counter active element is a 50 mg/cm² sheet of anthracene cleavings mounted with collodion on the face of an RCA 5819 photo-multiplier. The beta-counter subtends an angle of 0.07 steradian at the source, having efficiency 100 percent for beta- and 1 percent for gamma-rays. The beta-counter is fixed with respect to the source, the surrounding tank being evacuated to avoid loss of correlation by scattering. The sources are sufficiently thin (0.01 to 0.1 mg/cm²) so that no appreciable beta-scattering arises in the source.[1] Detailed tests indicate that the correlation measured is that existing at the atom in question. A coincidence resolving time of 0.04 microsecond is available from a simple modified Rossi pair.

Measurements are taken at 20 positions, giving 10 points of the correlation curve between 45° and 180°. For the most part, 20,000 counts are taken for each activity, and a $1+b\cos^2\theta$ function fitted by least squares to the experimental points. The observed beta-gamma-coincidence rate at each point is divided by the gamma-single rate at that point to allow for the shadow of the source holder, etc.

The resulting values for b and their standard deviations (induced through the least squares process by the finite number of counts) are listed in Table I.

TABLE I. Coefficient b in the function $1+b\cos^2\theta$ fitted by least squares to the experimental points.

Isotope	b
Na^{24}	$-0.02\ \pm 0.02$
Co^{60}	-0.003 ± 0.01
Ru^{103}	$+0.025 \pm 0.025$
Ru^{106}	-0.002 ± 0.009
Cd^{115}	$+0.02\ \pm 0.02$
Ir^{192}	-0.004 ± 0.03
Au^{198}	$+0.006 \pm 0.01$

In no case was any anisotropic correlation observed, larger than the statistical error. According to the theory[2,3] the only general way of obtaining spherical correlation is either for the beta-ray to be permitted or for the spin of the residual nucleus (after the beta-decay) to be 0 or ½. Typical values of the coefficient b range from 0.10 to 0.80 when these selection rules are not fulfilled.

For the isotopes Na^{24}, Co^{60}, and Au^{198} the spin of the intermediate nucleus is known to be non-zero,[4] and the beta-ray is classified as forbidden by Konopinski.[5] This suggests an inconsistency in the beta-ray theory, since the resulting angular correlations should be readily observable.

It is not known to what cause to ascribe the lack of correlation. The probability that these results are due to the operation of the selection rules in all cases, i.e., allowed betas or zero intermediate spins, is very small—of the order of 1 percent.[6,7] A large class of possible causes are made improbable by the fact that many gamma-gamma-correlations have been observed,[4] substantiating a considerable part of the theory.

Further experiments are under way on more test cases of the theory; these are forbidden beta-transition followed by a single gamma-ray to an even-even ground state.

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A fuller account of these investigations will be published in this journal.

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1 Pile irradiation of the sources, and some of the measurements were carried out at the Argonne National Laboratory. I should like to thank the staff of the Argonne Laboratory for their help and cooperation.

2 D. L. Falkoff, Ph.D. Thesis, University of Mich. (1948).

3 C. N. Yang, Phys. Rev. **74**, 764 (1948).

4 L. Brady and M. Deutsch, Phys. Rev. **74**, 1541 (1948).

5 E. J. Konopinski, Rev. Mod. Phys. **15**, 209 (1943).

6 In addition to the work reported here on the beta-gamma-problem, M. L. Wiedenbeck and K. Y. Chu inform me (August 10, 1949) that they have found no anisotropic correlation to 4 percent in Na^{24}, K^{42}, Co^{60}, Au^{198}, Cs^{134}, and I^{131}.

7 Also Na^{24} and Co^{60} at 90° and 180° by Grace, Allen, and Halban, Nature 164 (Sept. 24, 1949).