Letters to the Editor

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The Angular Correlation of Scattered Annihilation Radiation*

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AS early as 1946, J. A. Wheeler[1] proposed an experiment to verify a prediction of pair theory, that the two quanta emitted in the annihilation of a positron-electron pair, with zero relative angular momentum, are polarized at right angles to each other. This suggestion involves coincidence measurements of the scattering of both the annihilation photons at various azimuths. The detailed theoretical investigations were reported by Pryce and Ward[2] and by Snyder, Pasternack, and Hornbostel.[3] The predicted maximum asymmetry ratio of coincidence counts when the two counters are at right angles to each other to coincidence counts when the counters are co-planar is as large as 2.85 and occurs at a scattering angle of $\vartheta=82°$. Bleuler and Bradt[4] used two end-window G-M counters as detectors and observed an asymmetry ratio not inconsistent with the theory. Nevertheless, the margin of error associated with their results is so large that a detailed comparison between the theory and experiments is made rather difficult. In the meantime, Hanna[5] performed similar experiments with more efficient counter arrangements and found the asymmetry ratio observed to be consistently smaller than those predicted. Therefore, it appeared to be highly desirable to reinvestigate this problem by using more efficient detectors and more favorable conditions.

The recently developed scintillation counter has been proved to be a reliable and highly efficient gamma-ray detector. With this improved efficiency, which is around ten times that of G-M counters, there will be an increase in the coincidence counting rate of one hundred times. In our experiments, two RCA 5819 photo-multiplier tubes and two anthracene crystals $1\times1\times\frac{1}{2}$ in. were used. The efficiency for the annihilation radiation obtained with these anthracene crystals is seven to eight percent which compares favorably with the calculated value. The geometrical arrangement is schematically shown in Fig. 1.

The positron source Cu^{64} was activated by deuteron bombardment on a copper target in the Columbia cyclotron. The electroplating method was employed to separate Cu activity from other contaminations. The active Cu^{64} was packed in a small Al capsule of 8-mm diameter and 8-mm length. The annihilation radiation was collimated by a lead block $6\times6\times6$ in. with a $\frac{3}{8}$-in. channel drilled through the center of the block, such that the spread of the beam was found to be less than 3°. The aluminum scatterers were $\frac{1}{2}$ in. in diameter and 1-in. long. They were designed to absorb about 40 percent of the annihilation radiation lengthwise and to limit the multiple scattering of the radiation scattered at 90° to less than 15 percent. The crystal of the counter subtends an angle of 43° at the point in the scatterer where 20 percent of the incident radiation has been absorbed—that is, at the absorption midpoint of the scatterer. The mean scattering angle is very close to 82°, the predicted maximum of anisotropy. Under these conditions, the scattered radiation taken as the counting difference detected by the scintillation counter with and without the scatterer in place is three times the over-all background.

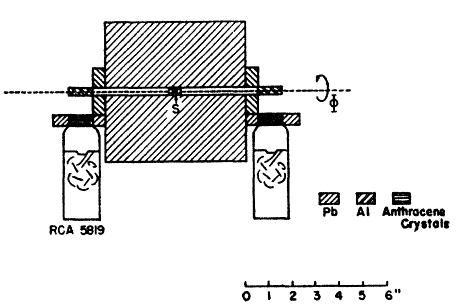

FIG. 1. Schematic diagram of experiment.

In taking the coincidence measurements, one detector was kept fixed in position, and the second detector was oriented to four different positions with azimuth differences (φ) of 0°, 90°, 180°, and 270° between the detector axis. After that, the second detector was kept fixed and the first one rotated. The total period of measurement lasted about 30 continuous hours. On account of the high coincidence rate observed (the true coincidence rates for the perpendicular position at the beginning was of the order of four per minute), the statistical deviations are much improved as compared to the results from G-M counters. The asymmetry ratio from our best run is

$$\frac{\text{Coincidence counting rate }(\perp)}{\text{Coincidence counting rate }(\parallel)}=2.04\pm0.08,$$

where ±0.08 is the probable mean error. The calculated asymmetry ratio for our geometrical arrangement is 2.00. Therefore, the agreement is very satisfactory. Further work is being planned to extend the investigations to more ideal geometrical conditions.

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The Optical Detection of Radiofrequency Resonance

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IN a recent paper under this title, Bitter[1] discusses the effect of a radiofrequency field on the optical Zeemann effect. He illustrates the question by treating an atomic system whose ground state is ^2S, making optical transitions to a ^2P state. The atoms are in a steady magnetic field H_z on which is superposed a rotating radiofrequency field H_0, in the xy plane, of angular frequency ω. According to Bitter, when there is a resonance between ω and $\omega_0=g\mu_0H_z/h$, the precession frequency of the spin moment in the ^2S ground state, certain observable changes happen to the Zeeman effect.

Such an effect certainly occurs, but Bitter's discussion is incorrect, and it is very doubtful if the effect could be observed in practice. Bitter calculates the frequencies of the Zeemann lines by means of a *mean energy* of the ground level in the presence of the radiofrequency field. This is a fallacious argument. The fre-