(1958).

[2]T. Kotani, Phys. Rev. 114, 795 (1959).

[3]H. Schopper, Phil. Mag. 2, 710 (1957); and Nuclear Instr. 3, 158 (1958).

[4]The notation of Kotani[2] is used throughout this paper.

[5]We are greatly obliged to Professor R. M. Steffen for enabling us to use his results prior to publication and for helpful discussions. According to his measurements $\epsilon(p^2/W)^{-1} = -0.09 \pm 0.001$ at $W = 4.3$.

[6]A similar curve could be derived from the shape factor $C(W)$. However, we did not add this curve as C is not known with reliability.

CIRCULAR POLARIZATION OF INTERNAL BREMSSTRAHLUNG ACCOMPANYING β DECAY

S. Galster and H. Schopper
University of Mainz, Mainz, Germany
(Received February 23, 1960)

As a consequence of parity nonconservation in weak interactions the particles emitted in β decay possess definite helicities. This is true even for second order processes. In a previous paper[1] it was shown that the photons emitted together with electrons and neutrinos are circularly polarized. For the K capture of A^{37} complete polarization (with positive helicity) was found[2] for the internal bremsstrahlung. The circular polarization of photons with negative helicity accompanying the β decay of Y^{90}, however, showed some deviations from the theoretical expectation.[1] This might be explained by systematic experimental errors or by the circumstance that the decay of Y^{90} is unique forbidden whereas the theory has been developed for allowed transitions only. In order to clarify the situation, the circular polarization of internal bremsstrahlung for different types of β transitions (allowed, first forbidden, unique forbidden) was investigated and all corrections were determined as accurately as possible.

The experimental setup was very similar to that used previously.[1] Compton forward scattering from magnetized iron was used to measure the circular polarization. The inner diameter of the scattering magnet (18 cm) and, at the same time, the length of the central lead absorber (14 cm) were increased in order to achieve a more effective absorption of the direct radiation. The electrons were stopped in paraffin so that the contribution from external bremsstrahlung was kept low. No correction was applied as this influence is negligible compared to statistical errors.

The difficulties in measuring the circular polarization of internal bremsstrahlung are twofold. The yield is very small ($\sim 10^{-3}$ photon/β decay) and thin sources must be used to avoid external bremsstrahlung produced in the source. This requires long counting times in order to get sufficient statistical accuracy. Secondly the spectrum of the bremsstrahlung drops very rapidly with increasing quantum energy. This circumstance, peculiar to bremsstrahlung, makes some corrections much more important than in other experiments. For example, the scattered photons degraded in energy have to compete with the direct radiation which penetrates the central lead absorber and has higher energy and hence a larger primary intensity.

In calculating the γ polarization from the measured change in counting rate (produced by reversing the magnetization), corrections were applied (a) for the elastic scattering of γ rays from the iron cylinder, (b) for Compton scattering from the copper of the magnetization coil, and (c) for photons penetrating the central lead absorber. These corrections are small for low photon energies but amount to about 30% at 1.5 Mev. Apart from these corrections the calculations were performed in the usual way.[3]

In order to avoid the production of external bremsstrahlung the sources and their backings had to be thin. Hostaphan foils (2 mg/cm^2) were used as backings. The sources were thinner than 2 mg/cm^2 and possessed activities of a few mC. A special procedure had to be used to prepare RaE sources.[4] RaE was deposited on Ni foils from RaD solution. As together with RaE some RaF which has a weak γ transition is deposited, a further separation was necessary. This was achieved by evaporating the RaE in a hydrogen stream and condensing it on cooled Al foils (~ 10 mg/cm^2) used as target backings in this case. Due to the short half-life of RaE, several sources had to be produced.

The experimental results for the three decays

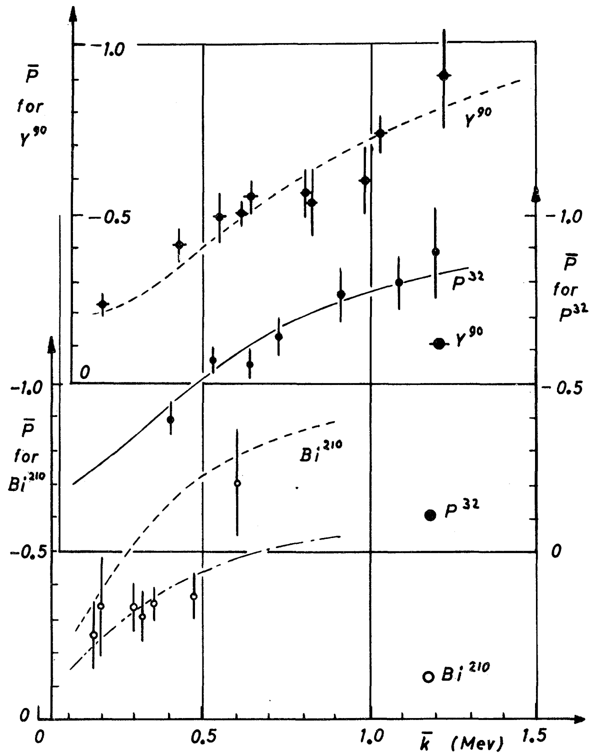

FIG. 1. The circular polarization P of internal bremsstrahlung as a function of the average photon energy $\bar{k}$ for the decays of P^{32} (allowed), RaE (first forbidden), and Y^{90} (unique forbidden). The full and dashed curves are calculated for allowed decays with $d=-1$, whereas for the long dashed curve of RaE the value $d=-0.62$ was used.

investigated are shown in Fig. 1. Different photon energies were observed by selecting the pulse heights with a single-channel discriminator. In order to compare the measured polarizations with theory, the polarization was calculated from the formula

$$P = dJ_2(k)/[J_1(k) + J_2(k)],$$

which has been derived by several authors.[5-7] J_1 and J_2 are functions of the photon energy k and are obtained by an integration over the electron spectrum. The quantity d is a combination of coupling constants and has for allowed transitions the value -1 for a V-A interaction with maximum violation of parity conservation. The polarizations plotted in the figure were evaluated by averaging over the finite energy resolution of the scintillation counter and by taking into account the presence of the Compton peak in the pulse-height distribution of a monoenergetic γ ray. Of course, these corrections must be applied to the measured polarizations and not only to the intensities. Details of these calculations will be published elsewhere.

The polarization of the allowed decay of P^{32} is in good agreement with the theoretical prediction, confirming nonconservation of parity in a second order process. As the theory for forbidden decays has not yet been developed, we compare the experimental results for Y^{90} and RaE with polarizations calculated for allowed decays. It turns out that the polarization of the unique forbidden decay of Y^{90} is in agreement whereas the results for RaE are consistently lower. Similar results were obtained for the longitudinal electron polarization. This similarity, however, is not trivial as the electron and γ polarizations need not be proportional to each other. Since a detailed theory is lacking, we tried to fit the results for RaE by an allowed curve, adjusting the parameter d, and obtained $d = -0.62 \pm 0.08$. This value is somewhat lower than that inferred from the electron polarization.[8]

We are indebted to Professor Strassmann for enabling us to produce the RaE source in his institute. It is a pleasure to thank Professor Bauer for putting at our disposal the electronic computer Zuse. We are obliged to the Bundesministerium für Atomkernenergie for supporting this work financially.

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[8]$P_{el} = -(0.75 \pm 0.02)(v/c)$; see H. Wegener, Z. Physik 154, 553 (1959).