LETTER TO THE EDITOR

Asymmetry of the positron emission by polarized $^{58}$Co-nuclei

Lee and Yang 1) have recently suggested that the law of parity should be given up for weak interactions and that consequently the intensity of beta-ray emission might differ in the directions parallel and antiparallel to the nuclear spin.

We have confirmed this prediction for the positron emission of $^{58}$Co. 8 microcuries of radioactive cobalt were contained in a 0.15 mm layer of Ce$_2$Mg$_3$(NO$_3$)$_{12}$.24H$_2$O grown on a large non-radioactive crystal, which could be cooled down by adiabatic demagnetization 2). The nuclear spins could be polarized in the vertical direction by means of a coil magnet producing a field of 300 Oe, according to the hyperfine structure polarization method 3). The emitted positrons were detected without introducing a particle counter into the cryostat by means of a device suggested to one of us (C.J.G.) in a discussion after a colloquium which he gave in Berkeley (Cal.) in 1952. The crystal was mounted with the radioactive layer downward and with the crystalline c-axis in the vertical direction. Positrons emitted downward in an approximately vertical direction were annihilated in a hollow glass cone placed in the vacuum at a distance of about 5 cm from the source, subtending a solid angle of about 4$\pi$/45. The annihilation radiation emanating from the glass cone was detected by two 2"-NaI-scintillation counters switched in coincidence which were placed in two diametrically opposed horizontal directions at 8 cm distance. The counters were shielded by the coil magnet and some additional lead against 0.805 MeV gamma rays and annihilation radiation from other parts of the cryostat.

The anisotropy of the emitted 0.805 MeV gamma rays was controlled by a third NaI-scintillation counter under an angle of about 15° with the axis of the magnetic field at a distance of about 35 cm. The gamma ray anisotropy amounted to about 0.07, from which it is concluded that a nuclear polarization of about 35% was obtained in the lowest range of temperatures (approximately 0.01°K). All counters were magnetically shielded and were found to be insensitive to reversal of the magnetic field within the statistical accuracy. The counting periods were 100 seconds. In this time interval each of the two diametrically placed counters gave about 50000 counts, whereas the number of coincidences of the two counters was about 150.

At the lowest range of temperatures and averaged over a number of runs, the number of coincidences with the magnetic field and consequently the nuclear spins upwards was 12 ± 3% lower than with the magnetic field downwards. The difference disappeared when the temperature rose considerably.

A few weeks ago 4) we learnt about a similar experiment carried out with electrons emitted by $^{60}$Co nuclei, carried out in Washington by Wu, Ambler, Hayward, Hoppes and Hudson 4). In that experiment a particle counter was mounted in the cryostat. It should be noted that the electron emission was largest opposite to the direction of the nuclear spin, whereas in our case positon emission occurs preferably
in the direction of the nuclear spin. The directional distribution of electrons or positrons emitted by polarized nuclei can be written as

\[ W_\pm(\theta) \propto 1 \pm eR(\mathbf{p}c/E)_f \cos \theta \ldots \]  

\( \theta \) is the angle between the direction of emission and the axis of polarization; \( f_1 = < I_z > / I \) is the degree of nuclear polarization; \( \mathbf{p} \) and \( E \) are the momentum and energy of the electrons; the upper signs refer to positrons, the lower signs to negative electrons. The value of \( R \) depends on the change of the nuclear spin in the \( \beta \)-transition. \( R = 1 \) if \( I_f = I_i - 1 \); \( R = 1/(I_i + 1) \) if \( I_f = I_i \); \( R = - I_i/(I_i + 1) \) if \( I_f = I_i + 1 \).

The value of \( \varepsilon \) may be \( \varepsilon = \pm 1 \) if \( C_T = \pm C'_T \); \( C_A = C'_A = 0; \) \( J(= 0) \) in the notation of Lee and Yang's paper 1). The value of \( R \) is \( R = 1 \) for \( ^{60}\text{Co}(I_i = 5; I_f = 4) \) and \( R = \frac{1}{2} \) for \( ^{58}\text{Co}(I_i = 2; I_f = 2) \). Hence the difference in sign of the effects for \( ^{60}\text{Co} \) and \( ^{58}\text{Co} \) arises from the essential sign difference for positrons and negatons, expressed in (1) and confirms the theoretical prediction made on the basis of Lee and Yang's parity non-conserving Hamiltonian.

Under the experimental conditions for \( ^{58}\text{Co} \): \( f_1 = 0.35 \) and \( \mathbf{p}c/E = \frac{1}{4} \), so that one should expect an anisotropy of at most \( 2 \times 0.33 \times 0.75 \times 0.35 = 0.175 \), a value which accepting the estimate of the ratio of the matrix elements for Gamow-Teller and Fermi interaction made by Griffing and Wheatley 5) decreases to 15%. In view of the correction for the background of the coincidences one arrives at the conclusion that the experimental result approximately agrees with the possibility \( C_T = - C'_T; \) \( C_A = C'_A = 0 \). This choice of the constants makes the formalism equivalent to a two component neutrino theory 6), which thus remains a very interesting theoretical possibility.

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