Physica XVIII, no 12 December 1952

INTERFERENCE TERMS AND SYMMETRY PRINCIPLES IN THE THEORY OF BETA DECAY WITH MIXED INVARIANTS

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In the theory of allowed β-decay [1] [2]), with the aid of an arbitrary linear mixture of invariants (1 = scalar, 2 = vector, 3 = tensor, 4 = axial vector, 5 = pseudo-scalar), one finds in the *spectrum* a factor

$$(C_1^2 + C_2^2)\,|\int 1\,|^2 + (C_3^2 + C_4^2)\,|\int \boldsymbol{\sigma}\,|^2 + \\ + C_5^2\,|\int \beta\gamma_5\,|^2 \mp (2\gamma/E)\,(C_1C_2\,|\int 1\,|^2 + C_3C_4\,|\int \boldsymbol{\sigma}\,|^2), \quad (1)$$

where the upper sign pertains to positive and the lower to negative β-decay. A factor like (1), but with 2 instead of $(2\gamma/E)$ is found in the probability of allowed K-capture. These factors are generally used to discuss the existence of the interference terms C_1C_2 and C_3C_4 (from form of spectrum, and from ratio of the probabilities of K-capture and β^+ emission) and the relative magnitude of Fermi-terms $(C_1^2 + C_2^2)$ and Gamow-Teller-terms $(C_3^2 + C_4^2)$.

If *β-neutrino angular correlation* is taken into account [2]), a new term,

$$-(v/c)\cos\theta\,\{(C_1^2 - C_2^2)\,|\int 1\,|^2 - \tfrac{1}{3}(C_3^2 - C_4^2)\,|\int \boldsymbol{\sigma}\,|^2 + C_5^2\,|\int \beta\gamma_5\,|^2\}, \quad (2)$$

must be added to (1). For complete determination of all mixing ratio's C_k, recoil experiments with ^{6}He alone are not sufficient, since $|\int 1\,| = 0$ for this nuclide. Results with a nuclide, having $|\int 1| \neq 0$ (such as ^{19}Ne), are also needed.

The preceeding is still not quite all that the theory of β-decay can give, because one can still take nuclear *orientation*, and *polarization* of β-particle (and neutrino) into account [3]). Then terms are found with coefficients

$$\pm C_1C_3,\ \pm C_2C_4,\ \pm C_3C_4,\ C_3^2,\ C_4^2,\ C_1C_4 \text{ and } C_2C_3. \quad (3)$$

It is indicated in (3) by $\pm$ that some of the interference terms show, as in (1), different signs for β^+ and β^- emission [4]).

Various symmetry principles [5]) have been postulated to diminish the number of possible linear combinations of interactions. In the symmetrical universal Fermi interaction, one finds a combination *STP*. It is interesting to note that, because in this interaction C_1C_3 is different from zero, a dissymmetry in β^+ and β^- emission arises according to (3). From a symmetry principle proposed earlier [2]) a dichotomy *SAP* or *VT* was found for possible interaction combinations [6]). One sees that for these interactions *all* interference terms in (1) and (3) would vanish, thus giving completely *symmetrical* β^+ and β^- emission.

Received 6-9-52.

REFERENCES

1) Fierz, M., Z. Phys. **104** (1937) 553.
2) de Groot, S. R. and Tolhoek, H. A., Physica **16** (1950) 456 (v. also Phys. Rev. **84** (1951) 150).
3) Tolhoek, H. A. and de Groot, S. R., Physica **17** (1951) 81.
4) For the direction of the electron spin, that of the angular momentum is chosen. With the less natural definition of spin direction as that of the magnetic moment, one would find no $\pm$ (i.e., β^+ and β^- emission same sign) before the first three terms in (3), but $\pm$ (i.e., different signs for β^+ and β^- emission) before the last four terms in (3).
5) A symmetry principle is meant as a description (or generalization) of the actual occurrence of mixed invariants, which might be a clue to a deeper theory of spin-one-half particles. It must be rejected or accepted on the basis of experimental evidence, not on formal arguments.
6) Discussion in: Trigg, G. L. and Feenberg, E., Phys. Rev. **82** (1951) 982; Biedenharn, L. C. and Rose, M. E., Phys. Rev. **83** (1951) 459; Tolhoek, H. A. and de Groot, S. R., Phys. Rev. **84** (1951) 150; de Groot, S. R., Intern. Conf. Nucl. Phys., p. 152, Chicago, 1951; Blatt, J. M., Marshak, R., ibid., p. 161.