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ASYMMETRY IN ANGULAR DISTRIBUTION OF NEUTRONS EMITTED IN THE CAPTURE OF NEGATIVE MUONS IN CALCIUM

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Submitted to JETP editor June 4, 1961

J. Exptl. Theoret. Phys. (U.S.S.R.) **41**, 306-307 (July, 1961)

FROM a measurement of the asymmetry coefficient of the angular distribution of neutrons from the reaction

$$\mu^- + A \rightarrow A' + n + \bar{\nu} \tag{1}$$

evidence about the nonconservation of parity and about the components of the weak interaction between a μ^--meson and a nucleon can be obtained. For the case of parity nonconservation, the angular distribution of the neutrons emitted by the nucleus in the direct process, bypassing the compound nucleus stage, is of the form[1]

$$N(E_n, \theta) \sim 1 + a\cos\theta, \qquad a = P_\mu \beta(E_n)\tilde{\alpha}, \tag{2}$$

where $\tilde{\alpha}$ is the asymmetry coefficient of neutron emission on capture of fully polarized μ^- mesons by the nucleus, a coefficient dependent only on the interaction constant of a μ^- meson with a nucleus; P_μ is the residual polarization of the μ^- meson in the K orbit of the mesic atom: $\beta(E_n)$ is a coefficient that takes the nuclear properties into account; E_n is the energy of the emitted neutron and Θ is the angle between the spin direction of the μ^- meson and the direction of emission of the neutron.

In the present note we report on preliminary results of measuring the asymmetry coefficient $\tilde{\alpha}$ on absorbing μ^- mesons in calcium. μ^- mesons with momentum 250 Mev/c (from the synchrocyclotron of the Joint Inst. for Nuc. Res.) were brought to rest in a calcium target of thickness 12 g/cm^2 placed in a magnetic field. The neutrons were recorded for 0.67 μsec, allowing 0.1 μsec after the passage of a μ^- meson, by a threshold scintillation layer detector, insensitive to γ quanta, similar to that described by us previously.[2]

Evaporated neutrons could be excluded from the count by choosing a 7-Mev threshold of neutron counting, and only neutrons from the direct process were detected with sufficient efficiency. The background of chance coincidences was measured simultaneously with the effect, with the same energy threshold.

A telescope of three scintillation counters recorded the disintegration electrons on stopping μ^- mesons in calcium in order to determine P_μ. The asymmetry in the angular distribution of neutrons and disintegration electrons was measured by the method of spin precession of a μ^- meson in a magnetic field, counting for two opposite directions of the magnetic field.

In spite of the four-layer magnetic shielding there was a slight influence of the coil magnetic field in the presence of the leakage field of the accelerator on the amplification coefficient of the photomultipliers of the neutron detector (FÉU-24), which was equivalent to a change in the working threshold by $(2.95 \pm 0.11)\%$. The effect of the field was carefully measured, and taking this into account we found

$$A_{\mathrm{Ca}} = P_\mu P_\gamma P_n \bar{\beta} \tilde{\alpha}_{\mathrm{Ca}} = -(0.067 \pm 0.022). \tag{3}$$

where $P_\gamma = 0.96$ and $P_n = 0.94$ are coefficients that take account of the recording of an insignificant fraction of γ quanta and evaporated neutrons produced in the capture of a μ^- meson; $\bar{\beta}$ is the mean of the quantity $\beta(E_n)$[1] averaged over the recorded part of the spectrum of primary neutrons and $P_\mu = 0.135 \pm 0.019$. From this $\tilde{\alpha}_{\mathrm{Ca}} = -(0.93 \pm 0.33)$.

As a control experiment we measured A_{Al} for μ^--meson capture in aluminum, where there is no asymmetry in view of the complete depolarization of μ^- mesons.[3] The measurements gave $A_{\mathrm{Al}} = -(0.015 \pm 0.015)$.

There have recently been reports[4,5] on the measurement of the asymmetry of neutron emission on the capture of μ^- mesons in magnesium and sulfur. The authors limited themselves to presenting the value of A and did not take the results as far as the calculation of $\tilde{\alpha}$. If a correction is made for the counting of evaporated neutrons in the way which we have used for calcium, then $\tilde{\alpha}$ from all these experiments has roughly the same value, near to unity, with the same (about 35%) statistical error. However, the lower neutron counting threshold (3 — 5 Mev) in these experiments leads to appreciable corrections P_n (0.5 — 0.7), making the value of $\tilde{\alpha}$ derived from [4] and [5] less reliable.

The existence of asymmetry of neutron emission which we have observed confirms the parity nonconservation in μ^- capture.[4,5]

On the basis of the theoretical[1] and measured values of $\tilde{\alpha}$, the presence of a pseudoscalar component of the interaction in process (1) can be deduced, with the sign of the ratio g_P/g_A of the pseudoscalar and pseudovector constants positive.

We must point out that the value of $\tilde{\alpha}$ obtained is appreciably greater than the most probable theoretical value $\tilde{\alpha} = 0.41$, obtained for $g_A/g_V = -1.25$, $g_P/g_A = 8$, $g_T/g_V = 3.7$.[1]

The authors consider it a pleasant duty to thank I. S. Shapiro, É. I. Dolinskii, and L. D. Blokhintsev for discussing the results of the present experiments, and Chang Jun-wa for help with the experiments.

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Translated by R. Berman
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CORRECTION TO "THE RELATIONSHIP BETWEEN MATRICES OF DIFFERENT TRANSITIONS AND MULTIPLE PROCESSES"

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Submitted to JETP editor February 25, 1961

J. Exptl. Theoret. Phys. **41**, 307-308 (July, 1961)

OUR earlier calculation[1] of multiplicity requires the following corrections.

1. Propagation functions in the Bloch-Nordsieck model were replaced incorrectly by $i(2\pi)^{-4}E_p^{-1}$. This approximation was based on the fact that

$$\prod_{i=1}^{n} S^c\left(p_f + \sum_{\alpha=1}^{i} k_\alpha\right) \sim E^{-n}$$

for $|\mathbf{k}_\alpha| \to 0$. Since this approximation is invalid for large $|\mathbf{k}_\alpha|$ the initial system of equations was solved anew for $V^{0n,22}$ [see Eqs. (9) and (10) in [1]], using a procedure proposed previously.[1,2] In the center-of-mass system we then obtain, instead of Eq. (15) of [1],

$$Q_n = \frac{g^{n+2}m^n\alpha_n(g, E)}{(n!)^{1/2}E_p^n}\prod_{i=1}^{n}\omega_i \Big/ \prod_{i=1}^{n}(\omega_i^2 - \mathbf{k}_i^2\cos^2\theta_i), \quad (1)$$

where E_p and ω_i are the energy of the nucleon and of the i-th meson in the final state, $\mathbf{k}_i^2 = \omega_i^2 - \mu^2$, and α_n is a function slightly dependent on n and E.

2. It is also necessary to perform a new integration over the final states. This had been done inconsistently in [1] and [2]. When we drop the hypothesis that the mesons are monoenergetic,[1] we must calculate

$$W_n = \int \frac{d^3p_1}{2E_{p_1}}\frac{d^3p_2}{2E_{p_2}}\frac{d^3k_1\ldots d^3k_n}{2\omega_1\ldots 2\omega_n}Q_n^2\cdot\delta^4\left(q_1 + q_2 - p_1 - p_2 - \sum_{i=1}^{n}k_i\right), \quad (2)$$

where Q_n is given by (1); a factor ensuring correct normalization of the final state[3] is taken into account in Q_n. Using a procedure similar to that proposed in [4] and [5], we can express W_n in terms of Hankel functions. However, multiplicity cannot be calculated for the general case. It must be assumed that the total momentum of the mesons is zero and that the transverse momentum of each meson is conserved ($p_\perp \sim \mu$). We then obtain approximately

$$W_n = (2\pi g m e^4\mu^{-2})^n E^{2n}n^{-5n}, \quad (3)$$

whence for the most probable number of created mesons in the c.m. system we have