ОБЪЕДИНЕННЫЙ ИНСТИТУТ ЯДЕРНЫХ ИССЛЕДОВАНИЙ
ЛАБОРАТОРИЯ ЯДЕРНЫХ ПРОБЛЕМ

V.S.Evseev, V.S.Roganov, V.A.Chernogorova,
Chang Run-hwa, M.Szymczak

E-1372

ANGULAR DISTRIBUTION OF NEUTRONS DUE TO μ^--CAPTURE IN CALCIUM FOR VARIOUS ENERGY THRESHOLDS

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It has been shown by Shapiro, Blokhintsev and Dolinsky[1,6] that one may obtain quantitative data on the μ^--capture interaction constants from the value of the asymmetry coefficient in the angular distribution of neutrons due to μ^--capture in nuclei.

Below are given the results of the asymmetry coefficient measurement for μ^--capture in calcium. One may draw the conclusion from this data that for high energy threshold of neutron detection the values for the asymmetry coefficient are close to -1 and do not agree with the value for the asymmetry coefficient calculated in ref.[1] basing on the universal weak interaction theory.

The angular distribution of neutrons emitted in nuclear absorption of polarized μ^-mesons is of the form[1-3].

$$N(\theta) \sim 1 + A \cos\theta \tag{1}$$

$$A = \tilde{a}\ \beta(E)\ \mathcal{P}_\mu\ \mathcal{P}_n\ \mathcal{P}_\gamma\ , \tag{2}$$

where θ is the angle between the direction of mu-meson spin and the direction of neutron emittance, P_μ is the residual polarization of the μ^--meson in the K-orbit of the mesonic atom, P_n and P_γ are the coefficients taking the detection of evaporation neutrons and gamma rays[2,3] into account, $\tilde{a}$ is the coefficient depending upon the interaction constant and neutrino energy, E is neutron energy, $\beta(E)$ is the coefficient taking into account nuclear properties[1]; normally in registering neutrons with the threshold detector the value of the coefficient $\tilde{\beta}(E_n)$ averaged over the detected part of the spectrum is taken, where E_n is the threshold of neutron detection.

Various groups of experimentators have measured the coefficient A in μ^--capture in some nuclei. The results of experiments performed for $E_n = 3-7$ MeV are summarized in refs.[2,3] where it has been shown that the experimental value $\tilde{a}$ may be close to -1, if the preference is given to the value $\tilde{\beta}(E_n)$ calculated by the shell model[1].

In the present note the results of measurements of A at various thresholds of E_n from 7 to 23 MeV are given[8].

Neutrons were registered by recoil protons with a laminated scintillation detector not sensitive to gamma-rays[4]. The angular distribution of neutrons was studied by the method of precession of μ^--meson spin in the magnetic field. In order to obtain the precession curves simultaneously at different thresholds of E_n photographing of the distribution $N(E_n, t)$ was performed. The values of A for various thresholds were found from the measured distribution:

$$N(E_n, t) = N_0 (1 + A \cos\theta)\ e^{-\frac{t}{\tau}} + c \tag{3}$$

where $\theta = \omega t + \frac{\pi}{2}$, ω is the precession frequency of μ^- meson spin, τ is μ^--meson lifetime in calcium; N_0, A, C are coefficients searched for by the least squares method with an electronic computer. In the second column of Table 1 are given the values of A which were obtained by using the lifetime in calcium $\tau = (0.333 \pm 0.007)\ 10^{-6}$ sec[5]. The value of $\tau = (0.335 \pm 0.008)\ 10^{-6}$ sec measured by us coincides with the previous one. In the third column of Table 1 are given the values of χ^2. the number of experimental points for each E_n is equal to 11. The count of recoil protons at the threshold $E_n = 7$ MeV is approximately 25 times larger than that at the threshold $E_n =$ 23 MeV. Fig. 1 shows the values of A versus E_n for $\tau = (0.333 \pm 0.007)\ 10^{-6}$ sec. and Fig. 2 shows one of the precession curves ($E_n =$ 19.5 MeV) corrected for lifetime.

Muon polarization P_μ was measured also by the precession method (by analogy with [2]) and turned out to be $P_\mu = 0.190 \pm 0.015$.

Since for higher thresholds P_n and P_γ are rather close to unity[2], then from the data of Table 1 it follows that for thresholds of $E_n \geq 19$ MeV the value for $\tilde{\alpha}\,\tilde{\beta}\,(E_n)$ is close to unity within $\pm$ 15%.

Usually[1,6] for the sake of comparison with the experiment the value $\tilde{\alpha}_{theor}$ is quoted which was calculated for the average energy in the neutron spectrum of the direct process for Ca^{40} $\tilde{\alpha}_{theor} = -0.41$[6] with $\lambda = -g_A/g_V = 1.25$, $\kappa = g_P/g_A = 8$ and $M = g_M/g_V = 3.7$, where g_V, g_A, g_P, g_M are the vector, pseudo-vector, induced pseudo-scalar and weak magnetism constants.

Apparently there are no nuclear effects which might provide the value $\tilde{\alpha}\,\tilde{\beta}\,(E_n)$ noticeably exceeding unity. Consequently, $\tilde{\alpha} = -(1 \pm 0.15)$.

Using the formula for $\tilde{\alpha}$ from ref.[1] we obtain that for higher thresholds $E_n = 20$ MeV $\tilde{\alpha}_{theor} = -0.34$ with $\kappa = 8$, and does not exceed the value $\tilde{\alpha}_{theor} = -0.52$ for each κ. Employing the same formula one may obtain that at the level of one experimenatl error in $\tilde{\alpha}$ $40 \geq \kappa \geq 18$

$$\lambda \geq 3.1$$

at the level of the doubled error $46 \geq \kappa \geq 12$

$$\lambda \geq 2.1.$$

One of the possibilities of interpreting this result within the universal weak interaction theory is given in ref.[7].

The detailed information on this investigation will be published in JETP.

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References

1. Akimova M.K., I.D.Blokhintsev, E.J.Dolinskii. JETP, 39, 1806 (1960).

2. V.S.Evseev, V.I.Komarov, V.Z.Kusch, V.S.Roganov, V.A.Chernogorova, M.M.Szymczak. Preprint P-759, 1961; Acta Phys. Polonica XXI, 313 (1962).

3. Evseev V.S., V.S.Roganov, V.A.Chernogorova, Chang Run-hwa, M.M.Szymczak. Proc. of 1962 Intern. Conf. on High-Energy Phys., p. 425 (1962).

4. V.S.Evseev, V.I.Komarov, V.Z.Kusch, V.S.Roganov, V.A.Chernogorova, M.M.Szymczak. Acta. Phys. Polonica, 19, 675 (1960); Pribory i Tekhn. Eksper. (Instrum. and Experim. Technique) No. 1, 68 (1961).

5. J.Sens. Phys. Rev., 113, 679 (1957).

6. E.J.Dolinskii, L.D.Blokhintsev. JETP, 35, 1488 (1958); 8, 1040 (1959).

7. M.L.Yovnovitch, V.S.Evseev. Preprint E-1373, Dubna, 1963.

8. Report on XIII Session of the Scientific Council of the Joint Institute for Nuclear Research, Atomnaya energ., 14, 502 (1963).

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E_n , MeV	$-A$	χ^2
7,0	0,054 ± 0,012	I9,6
II,0	0,I00 ± 0,0I6	I0,I
I4,0	0,I34 ± 0,020	7,6
I8,0	0,I93 ± 0,025	7,5
I9,5	0,234 ± 0,026	7,0
23,0	0,235 ± 0,040	5,0

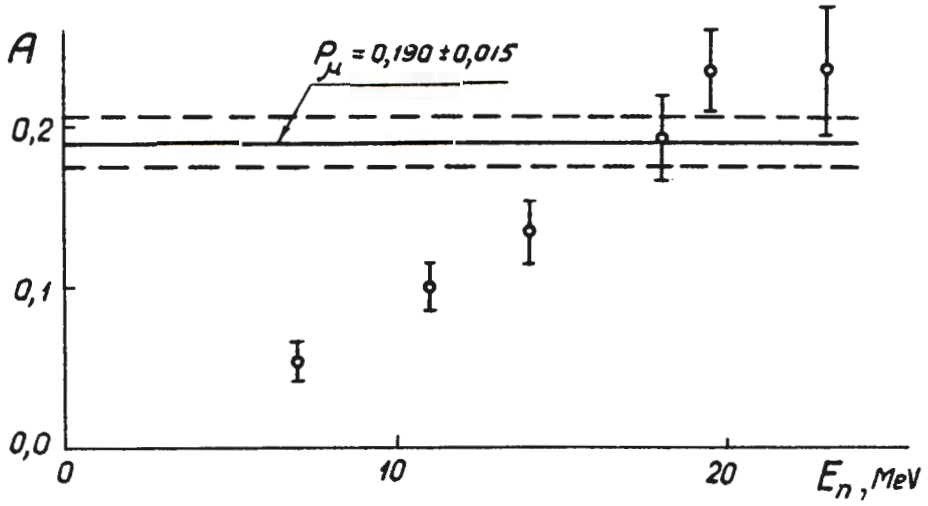

Fig. 1. Dependence of the asymmetry coefficient A upon the neutron detection threshold E_n.

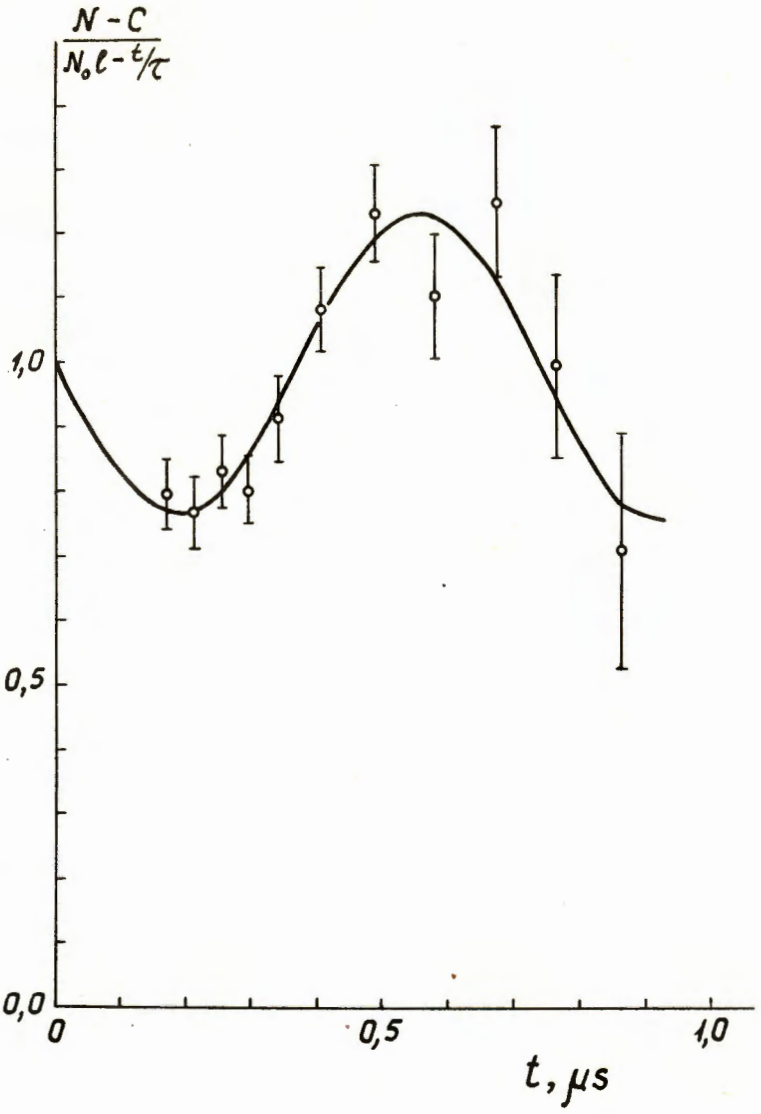

Fig. 2. Precession curve for E_n = 19.5 MeV.

Е-1372

Евсеев В.С., Роганов В.С., Черногорова В.А., Чжан Жунь-ва
Шимчак М.М.

Угловое распределение нейтронов от μ^--захвата в кальции для разных энергетических порогов.

На разных порогах регистрации нейтронов в интервале от 7 Мэв до 23 Мэв изучалась асимметрия в угловом распределении нейтронов $N_n \approx 1 + A_n P_\mu \cos\theta$ от μ^--захвата в кальции. Для порогов регистрации $\gtrsim 10$ Мэв измеренное значение коэффициента асимметрии близко к -1 с точностью $\pm 15\%$; остаточная поляризация μ^--мезонов равна $P_\mu = 0{,}190 \pm 0{,}015$. Полученные результаты противоречат универсальной теории слабых взаимодействий.

Работа издается только на английском языке.

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Evseev V.S., Roganov V.S., Chernogorova V.A., Chang Run-hwa, Szymczak M.

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Angular Distribution of Neutrons Due to μ^- Capture in Calcium for Various Energy Thresholds

On a various thresholds of neutron registration in the $7 \div 23$ MeV region assymetry in the angular distribution $N_n \sim 1 + A_n P_\mu \cos\theta$ of neutrons from μ^--capture in calcium was investigated. For threshold ≥ 10 MeV the measured value of assymetry coefficient is close to -1 within $\pm 15\%$; residial polarisaton of μ^--mesons was found to be $P_\mu = 0{,}190 + 0.015$. These resalts are in discrepancy with universal weak interaction theory.

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