P-parity violation in the reaction $^6Li(n,\alpha)^3H$ with polarized neutrons

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The P-odd asymmetry in the reaction $^6Li(n,\alpha)^3H$ has been measured in a beam of cold polarized neutrons at the VVR-M reactor at the Leningrad Institute of Nuclear Physics. The value found for the P-odd asymmetry coefficient, $\alpha_{PN}^{\rm exp} = -(6.4 \pm 5.5)\times 10^{-8}$, is much smaller than a theoretical estimate incorporating the well-defined cluster structure of the ^6Li and ^7Li nuclei.

The P-odd asymmetry of the type $W \sim 1 + \alpha_{pN}(\sigma_n \mathbf{k}_t)$ has been measured in the geometry $\vec{\sigma}_n \uparrow\uparrow \mathbf{k}_n \uparrow\uparrow \mathbf{k}_t$, where $\vec{\sigma}_n$ is the neutron spin, and $\mathbf{k}_t$ and $\mathbf{k}_n$ are unit vectors along the triton emission direction and the direction of incidence of the neutron. The experimental value of the P-odd asymmetry coefficient is, with allowance for the null experiment,

$$\alpha_{PN}^{exp} = -(6{,}44 \pm 5{,}50)\times 10^{-8}.$$

Parity violation in a few-nucleon systems $nd \to t\gamma$, $pp \to pp'$, $np \to d\gamma$, $^{18}F^* + \gamma$, etc., has recently been the subject of active experimental and theoretical research.[1–4] The purpose of this research has been to distinguish contributions from charged and neutral weak currents and to estimate the weak-interaction constants f_π and $h_{\rho,\omega}^{\Delta T}$. Studies of the P-odd asymmetry in the reactions $^6Li(n,\alpha)^3H$ and $^{10}B(n,\alpha)^7Li$, in which polarized thermal neutrons are captured with large cross sections, may result in very accurate measurements of P-odd effects. The development of the high-flux beam[5] of polarized cold neutrons at the VVR-M reactor of the B. P. Konstantinov Leningrad Institute of Nuclear Physics, Academy of Sciences of the USSR, has made it possible to improve the accuracy in measurements of P-odd effects by more than an order of magnitude over the previous measurements.

The present measurements were carried out in a beam of polarized neutrons with an integral flux $\sim 2\times 10^{10}$ n/s. The polarization was $P = 80\%$, and the average wavelength was $\lambda = 4$ Å. A multisection proportional chamber with wire electrodes was used in an ionization current mode (Fig. 1). There were 24 double chambers in succession along the path of the neutron beam. Half of a double chamber detected tritons emitted along the direction of the neutron's momentum, while the other half detected tritons emitted in the opposite direction. All halves of the double chambers working in the direction of the neutron's momentum (or in the opposite direction) were connected electrically for operation with a single preamplifier. The target consisted of a layer of ^6LiF deposited on aluminum foil with a thickness $d = 20\,\mu$m. For each

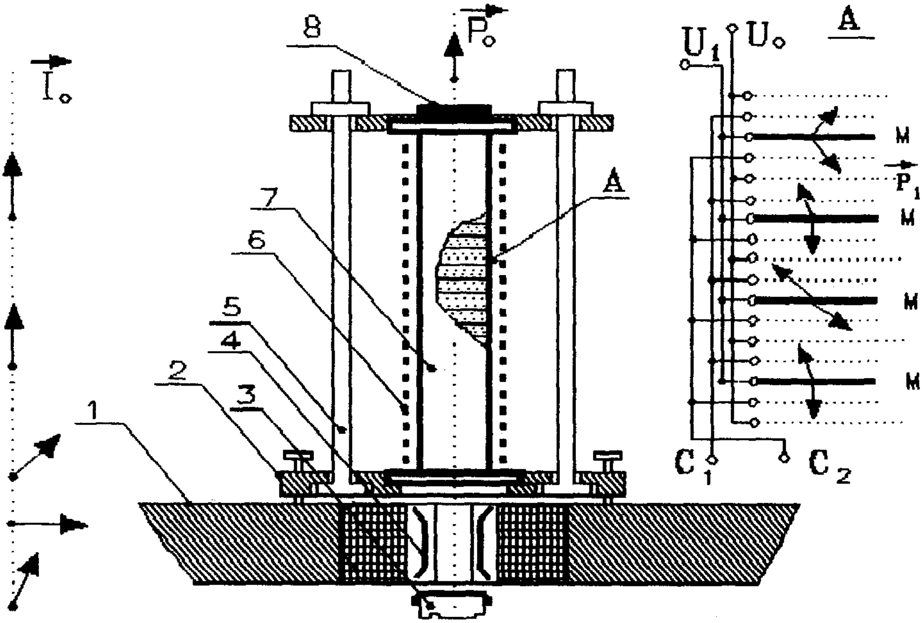

FIG. 1. Experimental layout. *1*—NRK cover; *2*—adjustment table of chamber; *3*—neutron duct; *4*—high-frequency flipper; *5*—chamber positioning system; *6*—coil for guiding magnetic field; *7*—chamber; *8*—^{6}LiF baffle; $\mathbf{I}_0$—neutron spin; $\mathbf{P}_0$—neutron momentum; $\mathbf{P}_1$—triton momentum. Section A: Diagram of one module of the chamber. C_1, C_2) Leads from the front-back signal grids; $U_{0,1}$) potentials applied to the blocking grid and to the target, respectively.

double chamber, two targets were used. The substrates of these butted each other. Each chamber thus had its own target, since 40 μm of aluminum completely absorbed the emitted tritons. The thickness of the targets for the first half of the chambers (the half nearer the point at which the beam entered the chamber) was $d = 400\ \mu g/cm^2$; that of the second half was $d = 600\ \mu g/cm^2$. Aluminum foil with a thickness $d = 10$ μm was cemented to each target to absorb α particles and to create the necessary solid angle of emission for tritons. The average cosine was $\cos(\vec{\sigma}_n \mathbf{k}_t) = 0.8$. The degree of beam absorption in the chamber was $\sim 90\%$. Because of the particular geometry used, the suppression factor for the left-right asymmetry $(\vec{\sigma}_n [\mathbf{k}_t \times \mathbf{k}_n])$ was no worse than 10^{-4}. A possible contribution of this asymmetry to the effect could thus be eliminated down to a level $\sim 10^{-8}$. The beam polarization was changed by means of an adiabatic flipper.[5] The method for compensating for reactor fluctuations and the measurement procedure are similar to those described in Refs. 6 and 7. The final result is

$$\alpha_{PN}^{\exp} = -(4.65 \pm 5.28) \times 10^{-8}.$$

To carry out a null experiment, the targets were covered with more aluminum foil, with a thickness $d = 20$ μm, to completely absorb the triton component. When we allow for the ratio of the background intensity to the intensity of the basic reaction, we find the result on the background to be

$$\alpha_b = (1{,}80 \pm 1{,}54)\times 10^{-8}.$$

When the result on the background is subtracted from the result of the main reaction, we find

$$\alpha_{PN}^{\mathrm{exp}} = -(6{,}44 \pm 5{,}50)\times 10^{-8},$$

The effect is to substantially improve the measurement accuracy over previous measurements:[6]

$$\alpha_{PN} = (0{,}7 \pm 8{,}0)\times 10^{-7}.$$

Among the various theoretical models which have been proposed to describe the appearance of P-odd effects at nuclei, the most promising in the case at hand is a model which incorporates the well-expressed cluster structure of the nucleus ^{6}Li.

Nesterov and Okunev[8] have shown that a calculation by this approach makes it possible to reduce the problem of the interaction of the nucleus with the neutron to a three-body problem. The theoretical estimate of the P-odd asymmetry which was found in Ref. 8 is $\alpha_{n\alpha}^{\mathrm{theo}} = (0.45 f_\pi - 0.06 h_\rho^0) \approx 3\times 10^{-7}$, for the "better" values of the weak-interaction constants, taken from Ref. 4:

$$h_\rho^{0\ b.v.} = -11.4\times 10^{-7}, \quad f_\pi^{\ b.v.} = 4.6\times 10^{-7},$$

This estimate is substantially larger than the value found in the present measurements. This discrepancy is evidence that the neutral current is small if the model of Ref. 8 is correct. A similar results has been found[9] in measurements of the circular polarization of γ rays ($E_\gamma = 1091$ keV) in ^{18}F. The corresponding experimental value of the constant of the weak neutral current, $f_\pi = (0.4^{+1.4}_{-0.4})\times 10^{-7}$ is substantially smaller than the theoretical estimate[4] ($f_\pi^{b.v.} = 4.6\times 10^{-7}$).

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[1]V. M. Dubovik and V. Zenkin, Ann. Phys. (NY) **172**, 100 (1986).
[2]E. G. Adelberger, Ann. Rev. Sci. **35**, 501 (1985).
[3]M. Kaiser and G. Meisser, NPA 499, 1989, p. 699.
[4]B. Desplanques *et al.*, Ann. Phys. (NY) **124**, 449 (1980).
[5]I. S. Altarev *et al.*, Pis'ma Zh. Eksp. Teor. Fiz. **44**, 269 (1986) [JETP Lett. **44**, 344 (1986)].
[6]V. A. Vesna *et al.*, Pis'ma Zh. Eksp. Teor. Fiz. **38**, 265 (1983) [JETP Lett. **38**, 315 (1983)].
[7]A. Antono *et al.*, Yad. Fiz. **48**, 305 (1988) [Sov. J. Nucl. Phys. **48**, 193 (1988)].
[8]M. M. Nesterov and I. S. Okunev, Pis'ma Zh. Eksp. Teor. Fiz. **48**, 573 (1988) [JETP Lett. **48**, 621 (1988)].
[9]A. B. McDonald *et al.*, Phys. Rev. C **35**, 1119 (1987).

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