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NEW MEASUREMENTS OF THE ANTINEUTRINO–SPIN ASYMMETRY IN BETA–DECAY OF THE NEUTRON AND RESTRICTION FOR MASS OF W_R

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Precise measurements of neutron beta decay parameters allow one to test the Standard Model of weak interactions. Particularly, measurement of the antineutrino–spin asymmetry with an accuracy better than 1% gives a possibility to check the existing models of right W–bosons in the neutron decay [1–3].

This work has been carried out on the vertical channel of cold polarized neutrons at the WWR-M reactor.

Measurement of momentum and angle of escape of the undetected antineutrino is possible due to detection of the electron in coincidence with the recoil proton and due to determination of their momenta.

One can show that antineutrino–spin asymmetry B can be expressed as

$$P \cdot B = \frac{[X(1 + a \cdot \frac{v}{c} \cdot (\cos\Theta_{e\tilde{\nu}})_{ik})] - A \cdot P \cdot \frac{v}{c} \cdot (\cos\Theta_{\sigma e})}{(\cos\Theta_{\sigma\tilde{\nu}})}, \qquad (1)$$

where X is the experimental asymmetry, a, A and B are coefficients of electron–antineutino, electron–spin, and antineutrino–spin asymmetries, P is the degree of neutron polarization. For determination of B it is necessary to know the beam polarization and calculated values

of $\frac{v}{c} \cdot \cos\Theta_{e\tilde{\nu}}$, $\frac{v}{c} \cdot \cos\Theta_{\sigma e}$ and $\cos\Theta_{\sigma\tilde{\nu}}$. The values of the correlation coefficients a and A can be taken from previous experiments [4, 5].

A necessary part of this experiment is the correct calculation of mean cosine values: $\frac{v}{c} \cdot \cos\Theta_{e\tilde{\nu}}$, $\frac{v}{c} \cdot \cos\Theta_{\sigma e}$ and $\cos\Theta_{\sigma\tilde{\nu}}$. To calculate these values a special Monte Carlo model of the beta decay process under real experimental conditions was developed.

The scheme of experimental setup is shown in Fig. 1. The decay region (4) is defined by means of a special diaphragm in front of the electron detector. The coincidences of signals from electron (1) and proton (2) detectors, located on the both sides of the decay region, are registered for opposite directions of neutron polarization. Decay protons which go through the time-of-flight cylinder (6) with their initial velocities are later accelerated and focused onto the detector (2) by an electric field with potential 25.6 kV applied between a spherical electrode (7) and spherical grid (8). The proton detector (assembly of two microchannel plates) allowed us to determine the time of flight of each proton with an accuracy of 10 nsec.

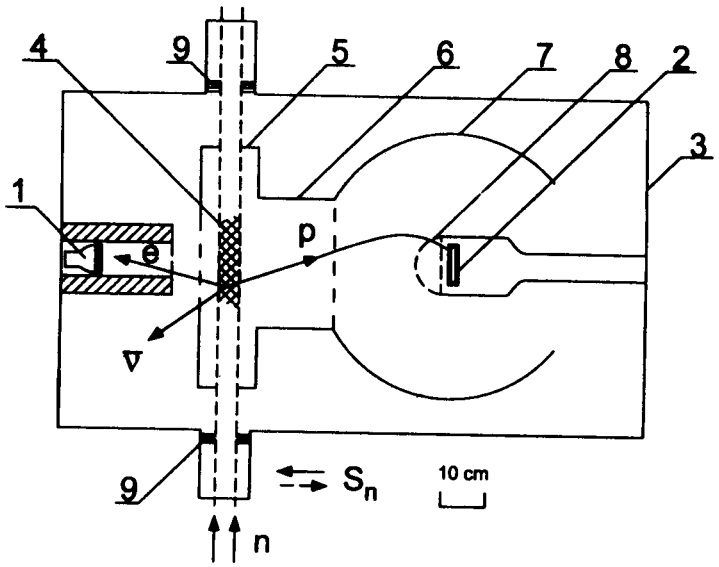

Fig.1. Experimental setup. *1* – electron detector; *2* – proton detector; *3* – chamber; *4* – decay region; *5* – cylindrical electrode; *6* – TOF cylinder; *7* – spherical electrode; *8* – spherical grid; *9* – **LiF** diaphragm

A special procedure of the analysis was organized for treatment of the experimental data, it allowed to obtain dependence of PB on $\cos\Theta_{\sigma\tilde{\nu}}$.

The results of treatment of the experimental data in the form of such dependence are presented in Fig. 2. The average value $PB = 0.6617 \pm 0.0044$ and $\chi^2 = 0.78$.

The possible systematic error of our result is equal to ± 0.0037. The main part of this error deals with the low resolution of the electron detector.

The polarization of the neutron beam was measured by a new method of precise determination of beam polarization [6]

$$P = 0.6688 \pm 0.0022 \qquad (2)$$

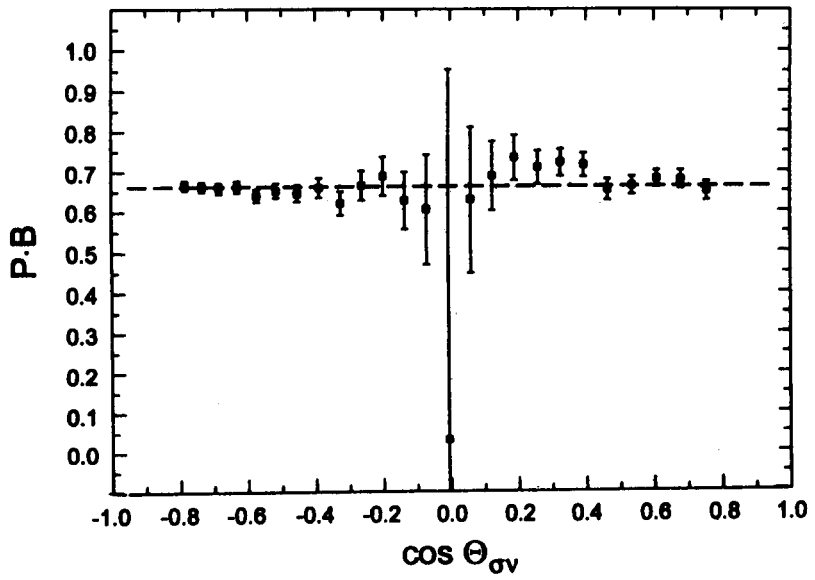

Fig.2. Dependence of PB on $\cos\Theta_{\sigma\vec{\nu}}$, obtained in this experiment

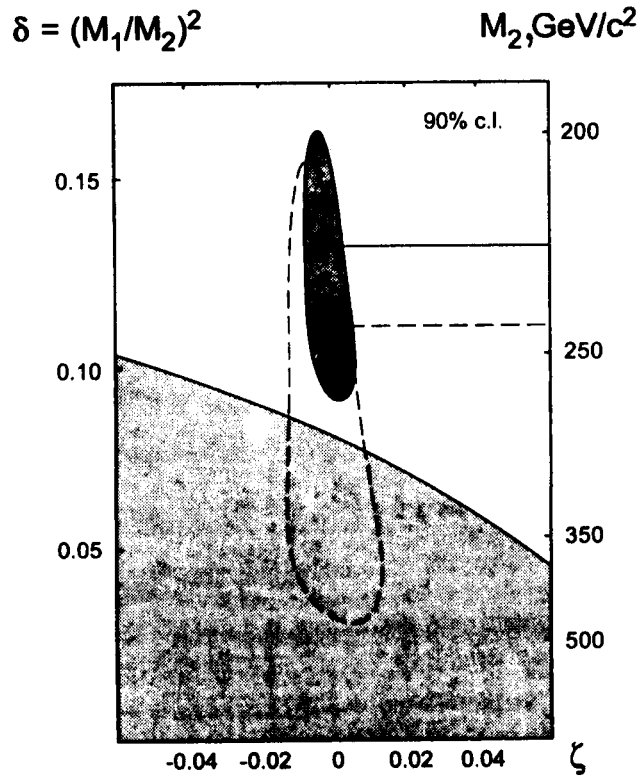

Fig.3. Restrictions for parameters of the left–right model arising from different experimental data. Darker shaded is the region allowed by experimental data on the neutron β–decay, nuclear $0^+ \to 0^+$ transitions and the decay of ^{19}Ne (the region surrounded by a dotted line – the same without data from [5]). The lighter shaded region comes from the present measurement

Using the values of PB and P, the following value of the antineutrino–spin asymmetry was obtained:

$$B = 0.9894 \pm 0.0083 \quad (3)$$

This result has an accuracy which is 4.2 times better than the previous measurement [7].

Using the obtained result, it is possible to give the restriction on the mass of the right boson W_R from the neutron β–decay. The value of the antineutrino–spin asymmetry is predicted in the frames of $V-A$ theory to be equal $B_{V-A} = 0.988 \pm 0.001$. According to the left-right model (at zero mixing angle) the value $B = (1-2\delta^2)B_{V-A}$, where δ is the squared ratio of left and right boson masses.

Since no difference between predicted and measured values is found within experimental errors of $\pm 0.83\%$, the restriction for right boson mass is $M_{W_R} > 282$ GeV/c^2 (90% CL). More complete analysis of restrictions from this experiment and previous ones is presented in the plane squared mass ratio (δ) *vs* mixing angle (ζ) – see Fig. 3. The figure includes experimental results for the neutron lifetime, neutron electron spin asymmetry, lifetime for $0^+ \rightarrow 0^+$ transitions, and lifetime and asymmetry in ^{19}Ne, which together suggest a mass about 230 GeV/c^2 for W_R. The results of our experiment fail to confirm the existence of this island directly from the neutron beta decay.

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PRECISE DETERMINATION OF NEUTRON BEAM POLARIZATION BY TWO ANALYZER METHOD

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The method of measurement of the neutron beam polarization by two analyzers was discussed in Ref.[1]. The main peculiarity of the method is the reversing of the neutron trajectories through the analyzing device. This method is extended by taking into account systematic errors and spin flipping in analyzers.

An accuracy of 0.2% in measuring the beam polarization in Ref.[1] was limited by a strong spectral dependence of the polarization and by a large angular divergence of the neutron beam.

To study a possibility of obtaining higher accuracy of the polarization, we constructed two devices with horizontal disposition of analyzers. The analyzing devices were constructed