$$\frac{i(E)}{i_0} = g \exp[-W_1(E)t] + (1-g)\exp[-W_2(E)t], \quad (5)$$

where g is the fraction of the ions in the state with J = 5/2 relative to the total number of excited ions; W_1 is the probability of their decay; (1 - g) and W_2 are respectively the fraction and probability of decay of the ions in the state with J = 3/2. The electric spectrum should consist in this case of two lines corresponding to the states $^2D_{5/2}$ and $^2D_{3/2}$, which may also not be resolved. Assuming splitting in accordance with J, we processed separately the measured relations (1) and (4). For the probability of decay in the field, we used for both states expressions (3) with different α and ε. The reduction yielded the same value of the binding energy (accurate to 2%) for the states $^2D_{5/2}$ and $^2D_{3/2}$, namely ε = 0.035 eV, and yielded values 1.12×10^5 and 2.8×10^4 for the coefficient α in formula (3) in the case of $^2D_{5/2}$ and $^2D_{3/2}$, respectively. We also determined the fractions of the states g = 0.6 and (1 - g) = 0.4, which agree exactly with their statistical weights.

Figure 2 shows the line contours of the individual states $^2D_{5/2}$ and $^2D_{3/2}$, calculated from formulas (5) and (3), as well as their summary curve, which describes well the experimental spectrum.

Thus, according to our data, the binding energy of the excited C^- ion in the state ^2D is (0.035 ± 0.0002) eV.

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MEASUREMENT OF THE ANGULAR CORRELATION BETWEEN THE NEUTRON SPIN AND THE ELECTRON MOMENTUM IN THE DECAY OF POLARIZED NEUTRONS

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Precision measurement of the coefficient of angular correlations in β decay of the neutron is of great importance for the explanation of the form of weak interactions.

The present paper is devoted to measurement of the correlation coefficient A, which is the factor of the scalar product of the neutron spin vector $\vec{\sigma}$ and the unit vector of electron momentum p_e in the expression for the β-decay probability [1]

$$W \sim [1 + A \frac{v}{c}(\vec{\sigma} p_e) + \dots] \qquad (1)$$

where v is the decay-electron velocity and c the velocity of light.

As seen from (1), to measure the coefficient A it suffices in principle to register only the decay electrons, while varying the direction of the polarization vector of the neutron beam

$$\mathbf{p} = \langle\vec{\sigma}\rangle/|\vec{\sigma}|.$$

In real background conditions, however, in order to identify the decay electrons it is necessary to register them in coincidence with the recoil protons. This raises the danger of the appearance of an important methodological error, due to the possible loss in the count of the recoil protons. Actually, the connection between the momenta of the electron, the proton, and the antineutrino, which are produced in the neutron decay act, leads to a dependence of the recoil-proton momentum on the antineutrino momentum. Therefore if the system for registration of the protons does not ensure independence of the counting efficiency of the magnitude and direction of the proton momentum, then the strong spin-antineutrino correlation gives rise, as can be readily verified, to a change in the coincidence counting rate when the direction of the polarization vector is changed. This introduces an error in the result of the measurement of the coefficient A.

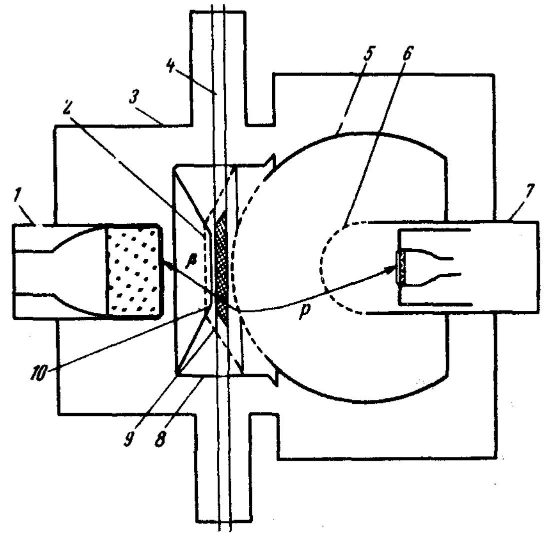

Fig. 1. Diagram of setup: 1 - electron detector, 2 - grid, 3 - vacuum chamber, 4 - neutron beam, 5 - spherical electrode with grid, 6 - small spherical grid, 7 - proton detector, 8 - screening electrode, 9 - conical grid, 10 - diaphragm separating the working region of the beam.

To avoid such an error, the working region of the beam is separated by a diaphragm on the side of the electron detector, thereby ensuring registration of all the decay protons corresponding to the registered electrons.

The work was performed with the IRT-M reactor of the Kurchatov Atomic Energy Institute. The coefficient of polarization of the neutron beam, measured by the Stern-Gerlach method [2], was P = 0.77 ± 0.02 at an intensity $\sim 3 \times 10^7$ n/sec. The beam and the polarization system were described in greater detail in [3, 4].

The experimental setup is shown in Fig. 1. The beam of polarized neutrons 4 passes through the vacuum chamber 3. Scintillation detectors for electrons 1 and protons 7 are located on both sides of the beam. The beam polarization vector is directed along the axis joining the counters. The working region of the beam (shown cross hatched in the figure) is separated by a diaphragm 10. This region is bounded by two grids, spherical 5 and conical 9. A potential difference of 2.5 kV is applied between the grids; this difference is sufficient for a complete "drawing out" of the protons produced in the working region through the spherical grid 5. The latter is part of a focusing system consisting of two spherical electrodes, 5 and 6. A potential difference of 30 kV is

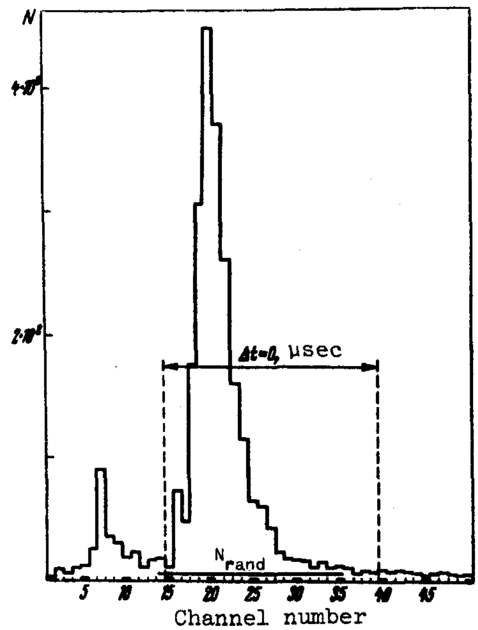

Fig. 2. Time spectrum of the recoil protons.

applied between them. The focusing system ensures acceleration of all the protons from the working region and their gathering on the detector; this was verified in special experiments.

The protons move in the focusing system for a finite time (0.25 - 0.8 msec), the time of flight being dependent on the initial momentum and on the proton trajectory. Figure 2 shows the time spectrum of the delay of the proton-detector pulses relative to the electron-detector pulses, and also the position of the time window in which the coincidences were counted, as well as the random-coincidence background level. Besides the peak connected with the protons, a second peak is observed, with a maximum in the channel corresponding to simultaneous operation of both detectors. This peak is of extraneous origin. Its contribution to the total count was ∿2.5% of the effect and was taken into account in the calculation of the correlation.

We counted the coincidences with periodic reversal of the direction of the neutron polarization vector $\vec{P}$.

The coincidence counting rate was about 200 counts/hr at an average random-coincidence background of 20 counts/hr. The difference between the coincidence counting rates (after subtracting the background) N_1 and N_2 for opposite directions of the polarization vector is equal to

$$x = \frac{N_1 - N_2}{N_1 + N_2} = kPA, \tag{2}$$

where P is the beam polarization coefficient and k is an apparatus coefficient that takes into account the averaging of expression (1) over the finite solid angles and velocities of the electrons.

The coefficient k was calculated by the Monte Carlo method. The value of the product in expression (2) was

$$kP = 0.548 \pm 0.025 .$$

We registered altogether about 60,000 events. The effect amounted to x = 0.0646 ± 0.045, corresponding to a correlation coefficient A = -0.118 ± 0.010. Within the framework of the V - A theory this yields $|\lambda| = 1.27 \pm 0.025$, where $\lambda = C_A/C_V$. These results are in good agreement with those of [5] (A = -0.115 ± 0.008, $|\lambda| = 1.25 \pm 0.02$).

We are continuing the measurement of the correlation between the neutron spin and the electron momentum and the refined results together with a detailed description of the experiment will be published later.

In conclusion, the authors consider it their pleasant duty to thank P.E.

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WKB METHOD FOR A STRONG COULOMB FIELD

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As is well known, the WKB method for the Schrodinger equation with a Coulumb potential leads to terms that coincide with the exact solution for all quantum numbers. The same holds true for the Dirac equation at $Z < 137$. On this basis it has been proposed (and confirmed by calculation) that for $Z > 137$ the electronic terms are well described by the WKB approximation for all quantum numbers.

Greatest interest attaches to the behavior of the lowest level $1s_{1/2}$, which is the first to reach the boundary of the lower continuum with increasing Z. To exclude striking the center, the nucleus was assumed to be finite (radius $R \ll 1$) and having a constant potential. The WKB method was used to find the term $1s_{1/2}$ in a field $V = -\alpha/r$ at $R > R$ and $V = -\alpha/R$ at $r < R$. Here $\alpha = Z/137$. The Dirac equation for the radial function $G(r)$ was transformed to the self-adjoint form $\phi'' + k^2\phi = 0$ by means of the substitution $G(r) = [1 + \varepsilon - V(r)]^{1/2}\phi(r)$, with

$$k^2 = \epsilon^2 - 1 + 2\epsilon\alpha/r + \alpha^2/r^2 - \frac{3}{4} r^{-2}[1 + r(1+\epsilon)/\alpha]^{-2} \qquad (1)$$

when $r > R$ and $k^2 = (\varepsilon + \alpha/R)^{\pm} - 1$ when $r < R$. A system with units $h = m = c = 1$ is used throughout. In order to satisfy the WKB condition at small values of r, the Langer correction $-1/4r^{-2}$ [1] was added to (1). We assume first $\varepsilon = -1$ and find the connection between Z_{cr} and R. The effective potential for this case is shown in Fig. 1. The Bohr quantization rule in a potential with a single vertical return wall has the form [2] $\int k dr = [n + (3/4)]\pi$. Applying this relation to the term $1s_{1/2}$, we obtain (assuming $R \ll 1$, which is actually always the case)

$$R = 2g_{cr}^2 \alpha_{cr}^{-1} \exp\left[-2 - \left(\frac{3}{4}\pi - \alpha_{cr}\right)/g_{cr}\right], \qquad (2)$$

where

$$g_{cr} = \sqrt{\alpha_{cr}^2 - 1}.$$

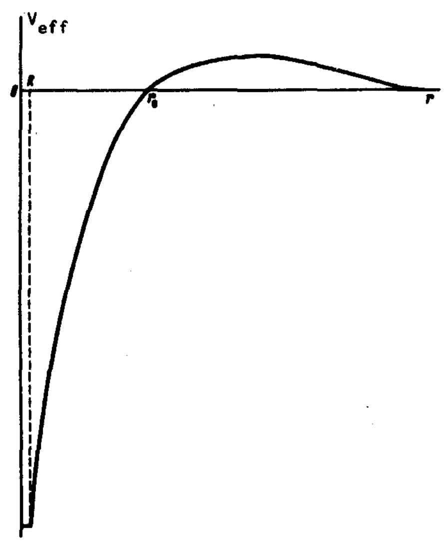

Fig. 1. Effective potential for $\alpha = \alpha_{cr}$.