NEW POSSIBILITY OF A SEARCH FOR A NEUTRON EDM BY POLARIZATION METHOD IN NEUTRON DIFFRACTION

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A new method of measuring a neutron EDM, using neutrons diffracted by a noncentrosymmetric quartz-crystal, is proposed. The method is based on the effect of depolarization of the diffracted neutron beams (direct and reflected) passed through the crystal. Description of the effect and the setup for its measurement is given.

Recently we have proposed a new polarization method for measuring values of the crystal fields E_g acting on neutrons under diffraction for Bragg angles θ_B close to $\pi/2$; a simple one-crystal setup [1] can be used in this method.

So we could determine experimentally the maximal sensitivity (the maximum value $E_g t$ where $t = L/v_{||} \sim (\pi/2 - \theta_B)^{-1}$ is the time a neutron spends in crystal, L is the crystal thickness and $v_{||}$ is the velocity of diffracting neutron moving along the crystallographic planes) attainable in this method for EDM measurements and the possibility of selection of sufficiently perfect crystals for this purpose.

In the present work, we have shown that polarization method could be also used for searching the neutron EDM, with not so much modification of the earlier proposed setup [2]. For example, it is necessary to provide for the rotation of crystal by angles about 180° as well as the duplex systems of polarization analyzers and neutron detectors for additional compensation of the parasitic effect connected with the Shwinger interaction (see the figure).

This method has some advantages (such as its relative simplicity and less sensitivity to crystal imperfection) over the method based on the spin dependence of the neutron Pendellosung phase [3].

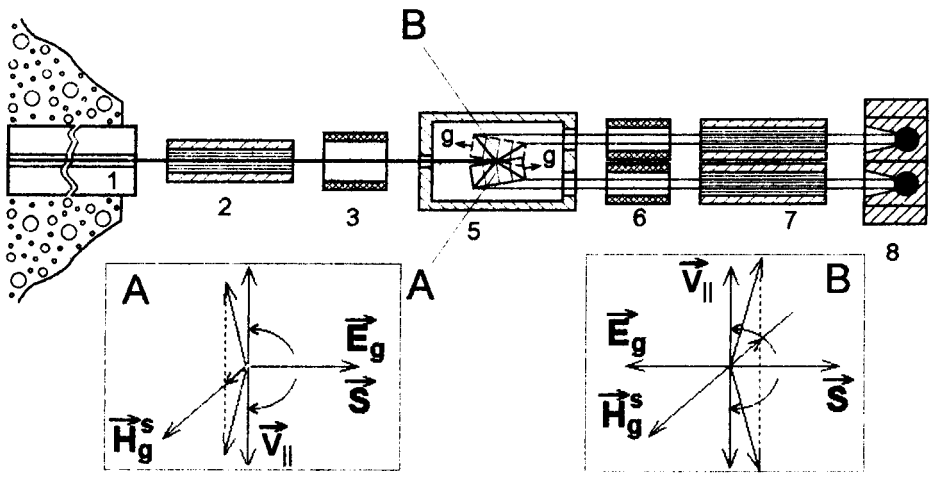

Fig. The possible setup for EDM searching. *1* is the reactor interchannel neutron-guide, *2* is the multislit neutron-guide polarizer, *3, 6* are the flippers, *4* is the α-quartz monocrystal, *5* is the magnetic shield, *7* is the duplex multislit neutron-guide analyzer, *8* is the duplex detector. A and B are the crystal positions different by the rotation angle $2\theta_B \simeq 180°$, $\mathbf{g}$ is the crystal reciprocal-lattice vector, $\mathbf{E}_g \parallel \mathbf{g}$

For the crystal thickness $L = L_0$ and the polarization of initial neutron beam along its direction (i.e. normal to the Schwinger magnetic field $\mathbf{H}_g = [\mathbf{E}_g \times \mathbf{v}_{||}]/c$) the spins for two kinds of the neutron Bloch waves inside the crystal will rotate in opposite directions by the angles $\pm\pi/2$, so the first half of neutrons will have the spins antiparallel to the other half. Therefore if the EDM is absent the polarization of the diffracted beams (direct and reflected) will be zero.

The existence of the EDM in this scheme leads to a slight beam polarization along the Schwinger magnetic field $\mathbf{H}_g$:

$$P_h \approx \frac{2DE_gL_0}{\hbar v_{||}}. \tag{1}$$

For crystallographic planes $(11\bar{2}0)$, EDM $D = 10^{-25}$ e·cm and $\pi/2 - \theta_B = 1/30$ ($L_0 = 3.6$ cm, $E_g = 2.1 \times 10^8$ V/cm) we shall have $P_h \approx 0.8 \times 10^{-4}$.

The polarization will have the opposite sign for the different crystal positions A and B (we should note that the residual polarization, if it exists without EDM, will have the same sign for both positions of the crystal).

We note that the maximum corresponding value of the spin rotation effect for the Bragg diffraction scheme [6] is $\sim 2.5 \times 10^{-6}$ (for the same crystal and thickness) that is 30 times less than in our case. Such a value for the Laue diffraction in hypotetical absorbing WC-crystal [7] is 7×10^{-6}. And there is no possibility to increase both these effects using the Bragg angles close to $\pi/2$ (as we can do in our case) because of the Bragg diffraction scheme in the first case [6] and the absorbtion in the second one [7].

The comparison with the most sensitive now magnetic resonance method using ultracold neutrons (UCN-method) [4,5] is given in Table.

Table

	UCN-method PNPI[4]	Diffraction of cold neutrons (Polarization method)
E (kV/cm)	10 - 15	2.1×10^5
t (s)	70 (v =5–6 m/s)	1.3×10^{-3} ($v_{||} = 27$ m/s)
Et (kV s/cm)	700 - 1050	280
N (neutrons/s)	60 - 80	2500

Data presented in the Table are given for cold neutrons of the vertical channel of the PNPI reactor WWR-M and for UCN from the universal liquid-hydrogen source of cold and ultracold neutrons. The crystal dimensions are $3.6 \times 14 \times 14$ cm^3. The crystallographic planes $(11\bar{2}0)$ are using (2d=4.9 Å) and $\pi/2 - \theta_B = 1/30$.

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REFERENCES

1. *Fedorov V.V., Lapin E.G., Voronin V.V.* Preprint PNPI-1993, NP-51-1994, Gatchina, 1994. 9 p. //PNPI Research Report 1992—1993, Gatchina, 1994. P.31.
2. *Fedorov V.V., Lapin E.G., Voronin V.V., Sumbaev O.I.* //Pis'ma ZhTF, 1995. V.21. No 21. P.50.
3. *Fedorov V.V., Voronin V.V. and Lapin E.G.* Preprint LNPI-1644, Leningrad, 1990. 30p. //J.Phys., 1992, V.G18. P.1133.
4. *Altarev I.S. et al.* //Phys.Lett., 1992. V.B276. P.242. Preprint PNPI-2055, NP-28-1995. Gatchina, 1995.
5. *Thompson D.* //Nucl.Instr.Meth., 1989. V.A284. P.40. *Smith K.F. et al.* //Phys.Lett., 1990. V.B234. P.191.
6. *Forte M.* //J.Phys., 1983. V.G9. P.745.
7. *Baryshevskii V.G., Cherepitsa S.V.* //Izvestiya Vuzov SSSR, ser. fiz., 1985. V.8. P.110.

COMPTON SCATTERING ON PROTONS BELOW PION PRODUCTION THRESHOLD: PROJECT OF EXPERIMENTAL DETERMINATION OF ELECTRIC AND MAGNETIC POLARIZABILITIES OF THE PROTON

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A new method is proposed for experimental determining the energy dependence of the differential cross section of elastic γp-scattering in the photons energy range from 20 to 120 MeV with a precision better than 1% in relative measurements. Such measurements should provide in a model-independent way the electric, $\overline{\alpha}$, and magnetic, $\overline{\beta}$, polarizabilities of the proton with errors of $\leq 0.5 \times 10^{-4}$ fm^3. This accuracy can be achieved with untagged bremsstrahlung γ-quanta produced by a 130 MeV, 10 μA continuous electron beam in several hundred hours of beam time. The method provides effective rejection of background reactions by detecting the scattered photon in coincidence with the recoil proton. The scattered photons will be detected and their energy measured with a large NaI(Tl) total absorption spectrometer with an intrinsic resolution of a few percent. The energy of the recoil protons will be measured in a special high pressure (100 bar) hydrogen ionization chamber that serves also as a target ($\simeq 3 \times 10^{22}$ protons/cm^2). The shape of the incident photon spectrum will be determined with the same NaI(Tl) spectrometer by detecting the events of elastic scattering on free electrons.

The scheme of the proposed ionization chamber (IC) and some parameters of the anode signals [1] are given in Fig. In order to keep the background caused by the Compton electrons and the e^+e^--pairs on an acceptable level, the anode of the IC is divided into twenty 2.5 mm wide strips separated by 0.1 mm gaps. The anode strips are directed along the tracks of the recoil protons. The kinematics of the reaction $\gamma + p \to \gamma' + p'$ in the investigated range of photon energies is such that, for fixed scattering angle $\theta_\gamma \pm \Delta\theta_\gamma$, the emission angle of the recoil protons $\theta_p(E_p) \pm \Delta\theta_p(E_p)$ practically does not depend on the photon energy E_γ, while $\Delta\theta_p \simeq (1/2)\Delta\theta_\gamma$. The value $\Delta\theta_\gamma = \Delta\varphi_\gamma$ is $\pm 5°$ for the chosen solid angle of the γ-