Observation of new diffraction effects at the set-up for searching a neutron EDM by crystal-diffraction method. Sensitivity of the method

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The sensitivity of the new proposed method [1] of a search for the neutron electric dipole moment (EDM) using Laue diffraction in a noncentrosymmetric crystal was experimentally investigated.
Study of a dynamical diffraction for the thick α-quartz crystal ($\sim$3.5 cm) and the Bragg angles close to the right one (up to 87°) was made for the first time for the direct diffraction beam. The following new effects were observed:

- Essential time delay of a diffracting neutron in a crystal for Bragg angles close to 90^0. It is shown that the time of neutron stay in crystal τ_L is not determined by total velocity of neutrons v, but its component $v_\parallel$ along the crystallographic plane. In particular, for (110) plane of α-quartz crystal and Bragg angle $\theta_B = 87°$ we have $\tau_L = (0.90 \pm 0.02)$ ms and $v_\parallel = (39 \pm 1)$ m/s, while $v = 808$ m/s.
- Effect of depolarization of a neutron beam was experimentally observed for the case of Laue diffraction by noncentrosymmetric crystal. It was experimentally demonstrated that the value of the effect (and, accordingly, value of interplanar electric field affecting on a neutron) does not depend on a Bragg angle and coincides with the theoretical prediction and results of the previous experiments. And the value of electric field turned out to be equal to $E_{(110)} = (2.24 \pm 0.05(0.20))10^8$ V/cm for the (110) plane of α-quartz crystal.
- It is experimentally shown that the value $E\tau$ determining the sensitivity of a method to neutron EDM in our case can be $0.2 \cdot 10^6$ V$\cdot$ s/cm (for Bragg angle equal to 87^0). This value is comparable with that of the UCN method ($0.6 \cdot 10^6$ V$\cdot$ s/cm [2]).

These results confirm the opportunity to increase more than an order of magnitude the sensitivity of the method to neutron EDM, using the diffraction angles close to 90°, and give a real possibility to exceed the sensitivity of the magnetic resonance method, using ultra-cold neutrons (UCN method).

References

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