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Present status of crystal diffraction nEDM experiment and related neutron optics phenomena

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Here we discuss a modern status of crystal diffraction experiment for searching the electric dipole moment of a neutron (nEDM) with the sensitivity comparable or exceeding that for the most sensitive now magnetic resonance method using ultra cold neutrons (the current best limit is $D_n < 3x10^{-26}$ e cm at 90% C.L. obtained at the ILL reactor in Grenoble resulted the long-term efforts of PNPI and ILL groups). The new limits on the nEDM value would be of great importance for understanding the nature of the CP violation as well as of the Universe baryon asymmetry.

Also series of experiments on neutron optics was carried out in Gatchina at PNPI reactor WWR-M to study the features of the neutron propagation through a crystal at nearly Bragg energies. The time of passage of the neutron through the crystal has been studied as a function of the deviation from the Bragg condition. The anomalous behavior of the dispersion of the neutron, i.e., the energy dependence of its average velocity, has been observed. It has been shown that the derivative dv/dE for the diffracting neutron at nearly Bragg energies can be three or four orders of magnitude larger than this derivative for a free neutron. This important fact should be taken into account in nEDM experiment, as well it opens new possibilities in precision neutron spectroscopy.

For example a method for measuring small changes in the neutron energy has been proposed on the basis of this anomalous dispersion behavior for the neutron in the crystal near Bragg “resonance.”A high sensitivity of the method allows the observation of the acceleration of the neutron in the alternating magnetic field. It has been found that the small difference between the energies of two spin states of the neutron (parallel and antiparallel to the magnetic field) leads to significant spatial splitting of wave packets and, correspondingly, to the depolarization of the neutron beam.

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