Measurement of spin rotation through non- centrosymmetric crystal

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1. Introduction

Non-zero value of the permanent electric dipole moment of neutrons (nEDM) signals the violation of time-reversal (T) invariance. Although experimental searches have been pursued in the world, the nEDM has not yet been observed. The present upper limit is $|d_n|<3\text{x}10^{-26}$ ecm (90% C.L.), which is very close to the predictions of new physics beyond the standard model of particle physics, for example, supersymmetry. The most stringent upper limit of the nEDM measurement was obtained in the spin precession frequency in both magnetic field and electric field of confined ultracold neutrons (UCN method). Although next-generation UCN sources are being developed intensively at accelerator-based neutron facilities for improving the upper limit with the UCN method, it is valuable and very important to develop different methods to measure the nEDM for confirming the present upper limit with different systematic uncertainties and hopefully improve the experimental sensitivity. The proposed experiment is the nEDM search using Laue diffraction of the cold neutrons in the noncentrosymmetric crystal. The nEDM would be measured as the non-vanishing spin rotation of polarized neutrons propagating with the diffraction in the noncentrosymmetric crystal.

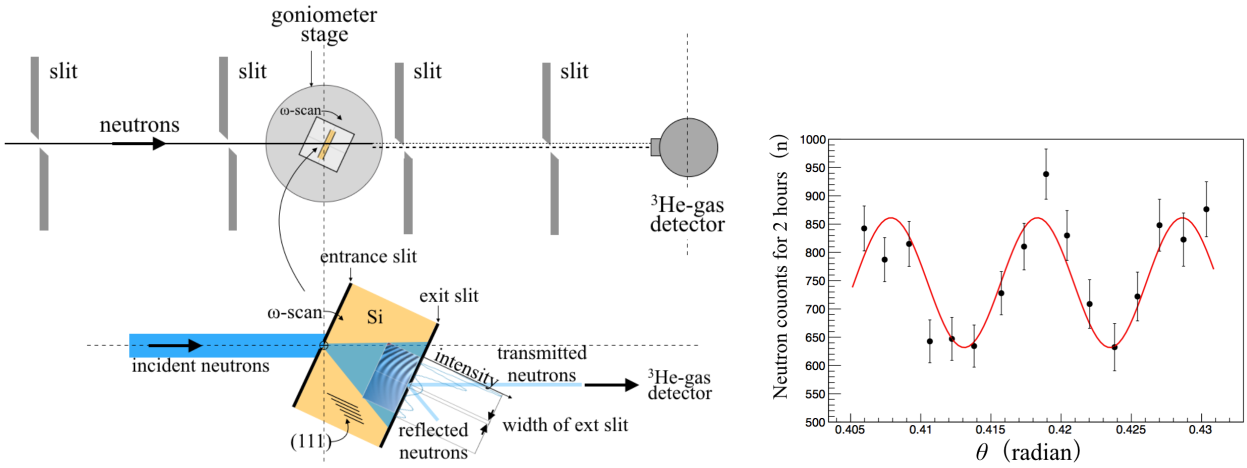
2. Experiment

We searched the optimized conditions for measuring Pendellösung interference fringes through the crystal, by using ‘silicon’. Neutrons with the proper incident angle are reflected and transmitted in the crystal according to Bragg's law. On the entry to the crystal, both waves are refracted due to the Fermi pseudopotential. In the case of the periodic boundary condition of the single crystal, the propagation of each wave can be written as a superposition of two Bloch functions. The two components of the transmitted neutron results in the interference, which can be observed as the spatial interference fringes called as “Pendellösung fringes”. The phase of the interference fringes depends on the length and the potential in the crystal.

The crystal was set on the goniometer in BL17. The crystal was covered by cadmium slit to select neutrons which transmit the crystal parallel to the crystal plane by dynamical diffraction. The neutrons with the wavelength of 0.2 nm was used to observe Pendellösung interference fringes. The transmitted neutrons are counted by using ^{3}He detector in BL17. The incident angle was scanned in order to observe the Pendellösung fringes.

3. Results

Clear Pendellösung interference fringes with contrast of 20% were observed by scanning of incident angle for the crystal. Now we can study to optimize a polarized neutron beamline with weak magnetic field to measure the electric field inside the crystal.



4. Conclusion

Pendellösung interference fringes using pulsed cold neutrons were observed for the first time. The observed fringes can be explained with the dynamical diffraction theory for the crystal. The coherent scattering length was accurately measured by using the period of the fringes. The time-of-flight analysis for a pulsed neutron beam enables the use of polychromatic neutrons for the observations of Pendellösung fringes and another physical observables with respect to several crystallographic planes at the same time. We expect that the simultaneous measurements on the planes would introduce an improved accuracy of physical observables that can be determined in their ratio.