【Grant-in-Aid for Scientific Research (S)】

Broad Section B

Title of Project : Search for the neutron electric dipole moment and the time reversal violation

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【Purpose and Background of the Research】

The current standard cosmology describes our Universe and its evolution starting from the Big Bang and following Inflation. The early Universe was in thermal equilibrium of particle-antiparticle annihilation. The Universe was cooled down by its expansion and the small amount of matter remained. Combined charge and parity (CP) reversal symmetry violation can be related to the matter-antimatter asymmetry. The standard model (SM) of particle physics describes the CP violation in the quark sector by CKM matrix. CP violation in neutrino sector was also observed by the T2K experiments. However, they are not enough to explain the matter-antimatter asymmetry in the present Universe. A new physics beyond SM is necessary.

A permanent electric dipole moment (EDM) of a fundamental particle violates time reversal (T) symmetry and therefore also CP symmetry assuming CPT conservation. The EDM is a good probe for searching a new physics beyond SM.

【Research Methods】

Ultracold neutrons (UCN) are neutrons of which kinetic energy is remarkably small (< 300 neV). Therefore, they can be stored in a material vessel. Neutron EDM (nEDM) is measured by observing the spin precession frequency of UCN in both the magnetic and electric fields. A high density UCN source is constructed and developed at TRIUMF (see Fig. 1). The UCN source enable us to measure the nEDM in the sensitivity of 10^{-27} ecm.

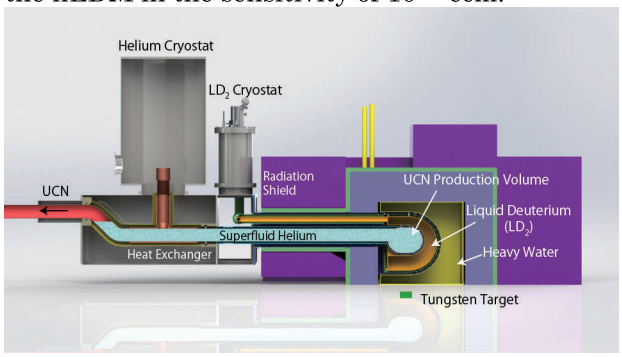

Figure 1 Schematic layout of the UCN source

Neutrons produced upon spallation reaction on the tantalum-clad tungsten target are moderated by room temperature heavy water. A large flux of cold neutrons around 1 meV is created by further moderation in 20 K liquid deuterium. Conversion to UCN happens in superfluid liquid ^{4}He around 1K where the cold neutrons are downscattered creating phonons and rotons in the liquid.

UCN are transported from the source to a storage vessel preserving their polarization. nEDM is measured by precisely observing the frequency of UCN spin precession in stable magnetic and electric fields using Ramsey resonance method. Systematic errors mainly arise from a geometric phase effect caused by gradients and fluctuations of the magnetic field. We will achieve uniform (< 1 nT/m) and stable (< 1 pT/100 s) magnetic fields by applying active compensation coils and a 4-layer shielded room.

【Expected Research Achievements and Scientific Significance】

SM predicts a nEDM at the level of 10^{-32} to 10^{-31} ecm. On the other hand, a new physics such as SUSY model predicts nEDM around 10^{-28} to 10^{-26} ecm. The current best experimental upper limit is 3×10^{-26} ecm measured with UCN at Institute Laue Langevin (ILL). We will search nEDM in the level predicted by new physics.

【Publications Relevant to the Project】

・R. Golub and J. Pendlebury, Phys. Lett. A 62, 337 (1977)
・J. M. Pendlebury et al., Phys. Rev. D. 92, 092003 (2015)
・Y. Masuda et. al, Phys. Rev. Lett. 108, 134801 (2012)

【Term of Project】 FY2018-2022

【Budget Allocation】 152,200 Thousand Yen

【Homepage Address and Other Contact Information】

http://fnp.kek.jp