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Development of a cryogenic device for a polarized target nuclei to search for the time-reversal symmetry violation in compound nucleus

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Understanding the matter-dominated universe requires the discovery of CP violation beyond the Standard Model. A promising approach is to search for time-reversal invariance violation (TRIV), which is equivalent to CP violation, using polarized neutron and polarized target nuclear reactions. Neutron transmission experiments are expected to be a particularly sensitive probe of TRIV effects by exploiting the same enhancement mechanisms that produce large parity violation (PV) in neutron-induced compound nuclear reactions [1]. The NOPTREX collaboration aims to realize the measurement at J-PARC MLF, with Lanthanum (La)-139 selected as the first target nucleus. For this nuclei, TRIV-to-PV cross-section ratio of 0.59 ± 0.05 was theoretically predicted, making it highly promising for the measurements of TRIV effects [2]. TRIV measurement using compound nuclear reactions requires the polarized nucleus target. Lanthanum-139 possesses a nuclear quadrupole moment and can be efficiently polarized up to about 50% through Dynamic Nuclear Polarization (DNP) using Nd-doped $LaAlO_3$ crystals [3]. To enable DNP under experimental conditions, we are developing a cryogenic equipment that incorporates a dilution refrigerator capable of reaching temperatures below 0.1 K and is compatible with an existing superconducting magnet. In this presentation, we will report on the current progress of the cryogenic system development for nuclear polarization.

[1] R. Nakabe, et al., Phys. Rev. C 109, L041602 (2024).
[2] T. Okudaira, et al., proceedings of J-PARC symposium 2024.
[3] P. Hautle and M.Iinuma, Nucl. Instrum. Methods Phys. Res. A 440, 638-642 (2000).

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