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Construction and performance test of improved magnetic field stabilization system for EDM measurement

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A permanent electric dipole moment (EDM) of a particle is the observable which directly violates the time reversal symmetry and hence the CP symmetry because of CPT theorem. The EDM has sensitivity to CP-violating phases contained in physics beyond the standard model (SM) of elementary particles. Thus, the search for EDM constitutes a stringent test which discriminates the gap between the SM and a model beyond it. We aim at measuring the EDM of ^{129}Xe atoms using a technique of the active nuclear spin maser. The EDM search to a size of $|d| = 10^{-28}$ ecm requires frequency precision of 1 nHz under an electric field of 10 kV/cm. The active spin maser enables us to sustain the spin precession of ^{129}Xe for unlimitedly long time. The long-term measurement is essential to improve the precision of the determination of the frequency because it is, in principle, proportion to $T^{3/2}$, where T denotes the measurement duration. We have achieved the precision of frequency determination of 9.3 nHz in a limited measurement duration of 30,000 s [1,2]. However the improvement in the precision seems to saturate for $T > 30,000$ s, presumably because of fluctuations in the external magnetic field. Further improvement in the precision may require reduction of the fluctuations in the external magnetic field.

Then, we have constructed a new experimental setup for the EDM measurement. The setup consists of a new triple-layer magnetic shield, a ferrite magnetic shield [3], and a coil to generate the static magnetic field. Each layer of the triple-layer magnetic shield has a cylindrical structure. The gaps between the layers are expanded to 200 mm for enhanced magnetic flux absorbencies. The shielding factor is measured to be 10^4 which is 10 times better than the previous one. A ferrite shield made of MnZn is expected to reduce a thermal noise thanks to its high magnetic permeability of about 2300 H/m. The coil is designed through simulation study, so that the homogeneity of the magnetic field in the center of the setup is optimized while the surface current in the shield generated by the coil is kept low. Performance of the composite setup will be given in the presentation.

[1] A. Yoshimi et al., Phys. Lett. A 376 (2012);

[2] T. Inoue et al., Physica E 43, 847 (2011);

[3] T. W. Kornack et al., Appl. Phys. Lett. 90, 223501 (2007).