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Search for Axion-like Particles with the nEDM Spectrometer at PSI

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on behalf of the nEDM Collaboration at PSI

There is so far no experimental evidence of CP violation found in the strong interaction. The non-observation of a neutron electric dipole moment (nEDM) constrains the CP violating term (θ-term) in the QCD Lagrangian to be nine orders of magnitude smaller than naturally expected [1]. A solution proposed in 1977 postulated that an additional symmetry, which was later called "Peccei-Quinn symmetry", could be introduced [2], replacing the static CP violating angle (θ) with a dynamic CP conserving field, which spontaneously breaks at some high energy levels. A new pseudo-scalar boson, axion, emerges as the Goldstone boson of this broken symmetry [3,4]. A short-range spin-dependent interaction which could be mediated by axions or other hypothetical bosons, which has similar properties as an axion and are normally called axion-like particles (ALPs), was brought forward in 1984 [5], which involves the $g_s g_p$ coupling.
Using the nEDM spectrometer at the Paul Scherrer Institute (PSI), we have searched for an interaction between polarized ultracold neutrons (UCN) and unpolarized nucleons in the bulk materials of the chamber wall, which could be mediated by ALPs [6]. This spin-dependent interaction can be regarded as a pseudo-magnetic field, which influences the spin-precession frequencies of stored UCN and ^{199}Hg atoms. With careful investigation on the frequency ratio between the two species, the coupling constant $g_s g_p$ can be derived. To achieve an improvement in sensitivity from the previous measurement in 2015 [6], two approaches were taken. First, an electrode of the precession chamber was replaced with a material of higher nucleon density. Second, the magnetic-field gradients will be analyzed by incorporating the field data recorded by online Cs-magnetometer arrays and offline field maps, to have a better control of the gradients. With this apparatus upgrade followed by dedicated analysis method, a sensitivity gain by an order of magnitude is expected. This study targets to achieve a new limit on the $g_s g_p$ coupling with an improved sensitivity, constraining the allowed parameter space of beyond Standard Model theories.

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