$\mathcal{P}$, $\mathcal{T}$-ODD FARADAY EFFECT: A NEW APPROACH TO IMPROVE THE SENSITIVITY OF THE SEARCH FOR TIME-REFLECTION-NONINVARIANT INTERACTIONS IN NATURE[a]

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A search for the time-noninvariant ($\mathcal{T}$-odd) interactions is one of the most fundamental not yet resolved problems in physics. The existence of the electric dipole moment (EDM) for any particle violates both $\mathcal{P}$- and $\mathcal{T}$-invariances ($\mathcal{P}$ is the space parity). The search for the EDMs continues for more than half a century without any success. The present constraint on the $\mathcal{P}$- and $\mathcal{T}$-violating effects is based on the observation of the electron-spin precession in an external electric field using the ThO molecule (ACME collaboration, USA). This experiment sets the upper bound for the electron EDM (eEDM) $d_e < 1.1 \times 10^{-29}$ e cm (e is the electron charge)[b]. An accurate evaluation of the eEDM within the standard model is still absent. The maximum estimated value is $d_e \sim 10^{-38}$ e cm[c]. No signs of "new physics" inside this gap between the theory and experiment have not yet been found. This encourages to suggest the new, more sensitive methods for observation of the eEDM in low-energy physics. We suggest considering the $\mathcal{P}$, $\mathcal{T}$-odd Faraday effect (rotation of the polarization plane for the light propagating through a medium in presence of an external electric field). The experiment is assumed to be performed with the modern intra-cavity/cavity-enhanced absorption spectroscopy techniques in combination with a molecular beam crossing the cavity[d]. Theoretical simulations of the proposed experiment with the PbF and ThO molecular beams together with accurate molecular structure calculations show that the present constraint on the eEDM in principle can be improved by a few orders of magnitude. An advantage of the $\mathcal{P}$, $\mathcal{T}$-odd Faraday experiment is that the $\mathcal{P}$, $\mathcal{T}$-odd effect is cumulated on the light, while in the ACME-like experiment it is cumulated on the molecules. For the shot-noise limited measurement, it is much easier to have a larger number of photons than a larger number of molecules.

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[b]V. Andreev et al. (ACME collaboration), Nature **562**, 355 (2018)

[c]M. Pospelov, I. Khriplovich, Sov.Nucl.Phys. **53**, 638 (1991)

[d]D.V. Chubukov, L.V. Skripnikov, L.N. Labzowsky, JETP Letters **110**, 382 (2019); D.V. Chubukov, L.V. Skripnikov, A.N. Petrov, V.N. Kutuzov, L.N. Labzowsky, PRA (2021) [Accepted, to be published; Preprint: arXiv:2102.05157]