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P,T-ODD FARADAY EFFECT: A NEW APPROACH TO THE SEARCH FOR THE P,T-ODD INTERACTIONS IN NATURE

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A search for the time-noninvariant (T-odd) interactions is one of the most fundamental not yet resolved problems in physics and, more generally, in nature. In 1950, Purcell and Ramsey [1] suggested that it is equivalent to the search for the electric dipole moment(EDM) of any elementary particle. The existence of EDM violates both P- and T-invariance (P is the space parity). The search for the EDMs continues already for 50 years without any success. In [2-3] it was predicted that in heavy diatomic molecules, the electron EDM (eEDM,d_e) can be greatly (up to 10^9 times) enhanced. The other possible P,T-odd effect in atomic systems - scalar-pseudoscalar interaction of an electron with atomic nucleus in an external electric field can be always presented as an existence of ''equivalent" eEDM $d_e^{\rm eqv}$ [3]. The most advanced recent experiment on the observation of eEDM in the ThO molecule (ACME collaboration, USA) sets the upper bound for eEDM $d_e < 1.1 \times 10^{-29}$ e cm (e is the electron charge) [4]. The accurate evaluation of eEDM within the standard model (SM) is still absent, the maximum estimated value is $d_e \sim 10^{-38}$ e cm [5]. No signs of "new physics" inside this gap of 9 orders of magnitude between the theory and experiment are not yet found. This encourages to suggest the new, more sensitive methods for observation of eEDM in atomic physics. Such a suggestion was made in [6-7] where the P,T-odd Faraday effect (rotation of the polarization plane for the light propagating through a medium in presence of an external electric field) was considered. The experiment was assumed to be performed with the modern ICAS (intra-cavity absorption spectroscopy) techniques which made important successes during the last decades [8]. Theoretical simulations of such experiments together with accurate calculations of the molecular structure showed that the sensitivity of the P,T-odd Faraday experiment on the PbF molecule can exceed the sensitivity of ACME experiment by 6-7 orders of magnitude. An advantage of the P,T-odd Faraday experiment is that the P,T-odd effect is cumulated on the light, while in ACME experiment (electron spin precession in an external electric field) it is cumulated on molecules. To surpass the shot-noise limit (which is the main condition to reach the higher sensitivity) it is much easier to have larger number of photons than the larger number of molecules. Then, using the nonlinear optical effects one may hope to close fully the gap between experiment and SM theory for eEDM.

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