Enhanced effects of violation of parity and time reversal invariance in molecules

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Effects of violation of the time reversal invariance (T) and parity (P) are strongly enhanced in atoms and molecules containing certain heavy deformed nuclei. These effects are used to measure T,P-violating nuclear forces, QCD theta-term, quark chromo-EDM, test Unification theories and search for dark matter in atomic and molecular experiments.

100-1000 times enhanced effects produced by the nuclear Schiff moment are associated with heavy nuclei with nuclear spin I>0 which have static octupole deformation or soft octupole vibration mode. Such nuclei (225Ra, 223Rn, etc.) are usually radioactive. Recently we found one stable candidate (153Eu) and several candidates with a very long lifetime [1-3].

Enhanced effects produced by the nuclear magnetic quadrupole moment require ordinary quadrupole deformation which exists in a half of all nuclei with the nuclear spin I>1/2 (they also have enhanced ordinary electric quadrupole) and non-zero electron angular momentum, i.e. paramagnetic molecules such as that used to measure electron electric dipole moment (EDM).

Effects produced by T,P-odd nuclear polarizability exist for any nuclear spin, incuding I=0, but require paramagnetic molecules such as ThO, HfF+, ThF+, YbF, YbOH used to measure electron EDM.

[1] Enhanced nuclear Schiff moment and time reversal violation in 229Th-containing molecules, V.V. Flambaum, Phys. Rev. C 99, 035501 (2019).

[2] Enhanced nuclear Schiff moment in stable and metastable nuclei, V.V. Flambaum, H. Feldmeier, Phys. Rev. C, 101, 015502 (2020).

[3] Electric dipole moments of atoms and molecules produced by enhanced nuclear Schiff moments, V.V. Flambaum, V.A. Dzuba, Phys. Rev. A 101, 042504 (2020).