Electric Dipole Moments – probes of fundamental symmetries

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The existence of a permanent electric dipole moment (EDM) of an elementary particle violates two fundamental symmetries, time reversal, $\mathcal{T}$, and parity $\mathcal{P}$. Assuming that the combined symmetry transformation, $\mathcal{CPT}$, is conserved by all interactions, $\mathcal{T}$ violation is equivalent to $\mathcal{CP}$ violation.

$\mathcal{CP}$ violation is of particular interest since it is required to explain the dominance of matter over anti–matter in our universe. The $\mathcal{CP}$ violation of the Standard Model is several orders of magnitude too small to account for this dominance. Additional $\mathcal{CP}$ violating interactions are needed. These could show up in permanent electric dipole moments of elementary particles.

Up to now, EDM searches focused on neutral particles, for example neutron, atoms and molecules because charged particles are accelerated in large electric fields and therefore can not be kept in small volumes. Storage rings with diameters >10m are required to allow for charged particle EDM measurements. Such storage ring projects for proton, deuteron and light nuclei are pursued at Brookhaven National Laboratory and at Forschungszentrum Jülich.