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Measurement of the permanent electric dipole moment of the neutron

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A nonzero permanent electric dipole moment (EDM) of a particle implies the violation of time-reversal symmetry. Considering CPT conservation, this also indicates the violation of the combined symmetry of charge conjugation and parity (CP), which is one of the three essential criteria to explain the baryon asymmetry of the Universe.

At the Paul Scherrer Institute, we measured the neutron EDM by applying Ramsey's method of separated oscillatory fields with stored ultracold neutrons (UCN) in vacuum at room temperature. In this experiment, a ^{199}Hg comagnetometer and an array of vapor ^{133}Cs magnetometers [1] were deployed to monitor, control, and correct for magnetic-field changes. In addition, dedicated measurements [2] were carried out to assess the systematic effects related to magnetic-field nonuniformity. Unprecedented understanding and assessment of systematic effects have been achieved. The statistical analysis was performed on blinded data [3] by two independent groups to avoid any bias on the data-selection criteria. The final value taken from the midpoint of the results from the two analysis groups, adding various systematic effects that have been estimated independently, gives $d_{\mathrm{n}} = (0.0 \pm 1.1_{\mathrm{stat}} \pm 0.2_{\mathrm{sys}}) \times 10^{-26}\, e \cdot \mathrm{cm}$. This may be interpreted as an upper limit of $|d_{\mathrm{n}}| < 1.8 \times 10^{-26}\, e \cdot \mathrm{cm}$ (90% C.L.), which sets the current best limit on the EDM of the neutron [4].

References:

[1] C. Abel et al. Phys. Rev. A 101, 053419 (2020).
[2] C. Abel et al. arXiv:2103.09039 [physics.ins-det] (2021).
[3] N. J. Ayres et al. Eur. Phys. J. A 57:152 (2021).
[4] C. Abel et al. Phys. Rev. Lett. 124, 081803 (2020).

Summary

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