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Searching for Physics beyond the Standard Model with Laser-Cooled Radium Atoms

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Laser cooling and trapping techniques have long been used for precision tests of physics, but never before have they been used to measure the electric dipole moment (EDM) of an atomic species. Such an EDM would violate time-reversal, parity, and charge-parity (CP) symmetries, which makes them a sensitive probe of expected physics beyond the Standard Model. However, to date, no such EDM has been found using any technique. Due to its large nuclear octupole deformation and high atomic mass, the radioactive isotope Ra-225 is a favorable EDM case; it is particularly sensitive to CP-violating interactions in the nuclear medium. We have developed a cold-atom approach of measuring the EDM of Ra-225 atoms held in an optical dipole trap, and last year demonstrated the method by completing the first measurement of radium's EDM. We have since improved on our first result by a factor of 36, reaching an upper limit of $|d(\text{Ra-225})| < 1.4\times10^{-23}$ e-cm (95% C.L.). This constitutes not only the first EDM measurement of any laser-cooled and trapped atom, but also the first such measurement on any species with an octupole deformed nucleus. Upcoming improvements are expected to dramatically increase our sensitivity, and significantly improve on the search for new physics in several sectors. This work is supported by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics, Contract No. DE-AC02-06CH11357.

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