Radioactive Molecules Are Dying to Reveal New Physics

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Rapid progress in the quantum control and interrogation of single atoms and molecules is opening new opportunities to explore the properties of atomic nuclei, as well as the fundamental particles and interactions that govern them. In particular, molecules containing heavy, radioactive nuclei with reflection-asymmetric shapes offer unprecedented sensitivity to measure parity- and time-reversal-violating nuclear properties. As a result, precision measurements in these systems are poised to address major open questions in our understanding of the universe, including the origin of the matter-antimatter asymmetry, the strong CP problem, and the possible existence of new particles. In this talk, I will present recent results and perspectives from precision experiments on these exotic species. I will also discuss how these systems are emerging as a key frontier in nuclear and particle physics, offering capabilities that complement and extend the reach of high-energy colliders and astrophysical experiments.