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Nuclear Clock and the Search for New Physics

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Nuclear Clock and the Search for New Physics

The isomeric transition in ^{229}Th - recently laser-excited by multiple groups [1] - opens a path to a nuclear clock with accuracy competitive with, and potentially exceeding, the best optical atomic clocks. Because the nucleus is well shielded from environmental perturbations, systematic shifts can be intrinsically small; however, the surrounding electrons strongly mediate excitation and decay via the electronic-bridge mechanism and can modify both transition frequency and lifetime by orders of magnitude [2]. Electron-induced shifts of the nuclear transition must therefore be quantified [3]. A “stretched-state” scheme suppresses leading-order electron–nucleus entanglement and mitigates key systematic effects [4].

The ^{229}Th transition is exceptionally sensitive to physics beyond the Standard Model: spatial/temporal variation of fundamental constants (α , quark masses, Λ_{QCD}) [5], ultralight dark-matter couplings to gluons and nucleons [6], and violations of Lorentz invariance and Einstein’s equivalence principle [7]. Four orders enhancement factors relative to electronic transitions, together with frequency-ratio networks linking nuclear and atomic references, enable stringent, model-aware constraints.

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