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Laser spectroscopy of a nucleus: The search for the isomeric transition in thorium-229[1]

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In 1976, Kroger and Reich established the existence of a low-lying nuclear excited state in Th-229 through the spectroscopy of gamma rays emitted following the alpha decay of U-233. The prospects of a laser-accessible nuclear transition touched off a flurry of proposals to utilize this apparently unique nuclear transition as a sensitive probe of both nuclear structure and chemical environment, to constrain the variability of the fundamental constants, to demonstrate a gamma-ray laser, and to construct a clock with unprecedented performance. However, while the last forty years have witnessed the confirmation of the existence of the state and a refinement of its energy to around 8 eV, measurements have yet to measure the transition energy precisely enough to allow the dream of laser spectroscopy of a nucleus. To directly measure this transition energy we have developed two experimental efforts. The first uses thorium-doped VUV transparent crystals as targets to observe the transition via laser-induced nuclear fluorescence. The second, in collaboration with the NIST-Boulder group, uses superconducting nanowires to measures the energy of internal conversion electrons produced in decay of the isomeric state. We will report the status of these experiments.

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