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Laser excitation of the low-energy nuclear transition in 229Th

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We report the first direct laser excitation of the Th-229 nuclear transition in Th-doped CaF2 crystals using a tabletop tunable laser system. The Th:CaF2 crystals are grown at TU Wien with up to 5×10^{18} cm^{-3} Th-229 concentration, and a VUV laser system developed at PTB, that provides a spectral photon flux of more than 2×10^4 photons/(s Hz).

A resonance fluorescence signal is observed in two crystals with different Th-229 dopant concentrations, while it is absent in a control experiment using Th-232. The nuclear resonance for the Th^{4+} ions in Th:CaF2 is measured at the wavelength 148.3821(5) nm, frequency 2020.409(7) THz, and the fluorescence lifetime in the crystal is 630(15) s. Because of the higher density of photon states in the dielectric optical medium, the measured spontaneous M1 decay rate is expected to be enhanced relative to the rate in vacuum by a factor n^3 where n is the refractive index. Applying this correction, the measured radiative lifetime of 630(15) s corresponds to an isomer half-life in vacuum of 1740(50) s.

These results pave the way towards high-resolution Th-229 nuclear laser spectroscopy and realizing optical nuclear clocks.

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