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Performance of a 229 Thorium solid-state nuclear clock

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The 7.8 eV nuclear isomer transition in 229 Thorium has been suggested as an etalon transition in a new type of optical frequency standard. Here we discuss the construction of a "solid-state nuclear clock" from Thorium nuclei implanted into single crystals transparent in the vacuum ultraviolet range. We investigate crystal-induced line shifts and broadening effects for the specific system of Calcium fluoride. At liquid Nitrogen temperatures, the clock performance will be limited by decoherence due to magnetic coupling of the Thorium nucleus to neighboring nuclear moments, ruling out the commonly used Rabi or Ramsey interrogation schemes. We propose a clock stabilization based on counting of flourescence photons and present optimized operation parameters. Taking advantage of the high number of quantum oscillators under continuous interrogation, a fractional instability level of 10^{-19} might be reached within the solid-state approach.

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