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Exciting the Thorium-229 isomer in a crystal

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Abstract

The isomer of Th-229 is the only excited nuclear state known today that could be excited by current laser technology. Its extremely low energy (8.26 eV [1]) stems from its unique elliptical shape which creates a near degenerate ground state. Owing to its long lifetime, the Th-229m isomer could form a platform for a future nuclear optical clock. Recently, the LMU Munich experiment has observed the internal conversion de-excitation of the isomer and determined its energy [1, 2]. The radiative decay has not yet been observed. We aim to create a population of Th-229 isomers doped in a CaF2 crystal to observe the radiative decay of the isomer. Firstly, the biggest challenge of using Th-229 in a crystal is understanding the interactions between the nucleus and the crystal system. Internal conversion via crystal interaction is still an open question and defects decrease the transparency of the crystal. The suppression of both the non-radiative decay of the isomer and crystal defects are necessary for the detection of the radiative decay. We employ several methods to attempt to create a detectable population of isomer nuclei in the crystal system. To excite the Th-229 in the crystal, we grow these doped crystals and take several new approaches: firstly we apply a commercially available excimer lamp [3]. The excimers show a continuous and broad emission spectrum in the VUV region, thus are able to directly excite the isomer. Secondly, we use x-rays created in the SPring8 synchrotron to resonantly excite the 2nd nuclear excited state [4]. This state directly decays to the isomer state thus creating a population of isomer nuclei in the crystal. Thirdly we dope CaF2 with Uranium-233 and use the radioactive decay of Uranium to create isomer nuclei in the crystal system [5].

References

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