# Researchers move closer to switching nuclear isomer decay on and off

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Livermore researchers have moved one step closer to being able to turn on and off the decay of a nuclear isomer.

The protons and neutrons in a nucleus can be arranged in many ways. The arrangement with the lowest energy is called the ground state and all others are called excited states. (This is analogous to the ground and excited states of electrons in an atom except that nuclear excited states are typically thousands of times higher in energy.) Excited nuclear states eventually decay to the ground state via gamma emission or to another nucleus via particle emission. Most excited states are short-lived (e.g., billionth of a second). However, a few are long-lived (e.g., hours) and are called isomers.

Turning the decay on and off is key to using isiomers as high-energy density storage systems such as batteries.

Researchers at Livermore studied an isomer of Thorium-229. This isomer is unique in that its excitation energy is near optical energies, implying that one day scientists may be able to transition Th229 nuclei between the ground and isomeric states using a table-top laser.

"This would then be the first time human control would be exerted over nuclear levels," said Peter Beiersdorfer, an LLNL physicist and co-author of a paper that appears in the April 6 issue of *Physical Review Letters*. "This only works if the laser is tuned to exactly the correct energy."

For years, researchers have been fascinated with this isomer because it could lead to new science and technology breakthroughs. Among them are: a quantum many-body study; a clock with unparallel precision for general relativity tests; a superb qubit (a quantum bit) for quantum computing; testing the effects of the chemical environment on nuclear decay rates. Isomers also may serve as a battery for storing large amounts of energy.

However, before these exotic studies can be performed, an accurate determination of the isomer’s excitation energy above the ground state is needed. In the most recent research, Livermore scientists, along with colleagues from Los Alamos National Laboratory and NASA Goddard Space Flight Center, have made the most accurate measurement of this energy difference using an indirect technique.

"Our measurement is more accurate and differs significantly from prior results. This may explain why scientists have failed to directly see this transition. Frankly, they were looking in the wrong place," said Bret Beck, an LLNL physicist and lead-author on the paper.

The next step will be to use a laser or a synchrotron tuned to the exact energy of the spacing between the two levels and observe the transition from the ground state to the isomeric state.

Once laser excitation has proven possible, helping an excited level decay (and thus give off energy) can be tackled. "But for building a more precise clock than we have today, or building a quantum computer, excitation may be all that’s needed," Beiersdofer said.

Source: Lawrence Livermore National Laboratory