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Direct Detection of the Elusive 229mTh Isomer: Milestone Towards a Nuclear Clock

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The isomeric first excited state of 229Th possesses the lowest excitation energy of all known nuclei.
Its energy has been predicted to be 7.6 eV [1] and could in principle allow to populate this isomeric state with state-of-the-art lasers. This has led to multitude of proposed applications, the best known therein is a nuclear optical clock, that could outperform today's existing atomic optical clocks. However, progress has so far been hindered by the vague and indirect knowledge of the transition energy and lifetime of the isomeric state.
The isomer decays via several decay channels to its ground state, whose strength depends on the electron environment of the nucleus: internal conversion (IC) decay occurs as soon as the binding energy of an electron in the surrounding of the nucleus is below the energy of the isomer.
Other decay channels are regular γ decay or bound internal conversion, where a bound electronic state is excited.
The measurements that led to the first direct detection of the isomer, as well as recent measurements of the internal conversion decay lifetime of neutral 229mTh, are presented in the talk:
In our experimental setup, 229mTh is populated via a 2% decay branch of the 233U α decay.
Therefore a 233U α recoil source is placed in a buffer gas stopping cell, filled with ultra-pure helium that thermalizes the 229(m)Th recoil ions.
The ions are extracted in a gas jet into a segmented radio frequency quadrupole (RFQ) that allows for beam cooling and bunch creation.
Behind the RFQ, other daughter nuclei from the 233U decay chain are removed with a quadrupole mass separator and a charge state of the ion can be selected.
The 229(m)Th ions are then collected directly on an MCP detector that is used for neutralization of the ions and for the subsequent detection of the internal conversion electron emitted during the ground-state decay of the isomer [2].
With the creation of ion bunches with a width of 10 µs, it was possible to determine the half-life of the internal conversion decay to be 7(1) µs [3].
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References:
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