Decay of the $K^{\pi}=23/2^{-}$ Isomer ($T_{1/2}$=160.44 d) in ^{177}Lu: Revisited

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Gamma-ray spectroscopy studies of K isomers play an important role in understanding properties of deformed, axially symmetric nuclei. While considerable progress has been made in the past 30 years to describe the excitation energy and quantum numbers of many isomers located in different areas of the nuclear chart, prediction of their lifetimes still remains a challenge for theory. The lifetimes can be particularly long, especially when the isomer is classified as being both a K-trap (large difference in K quantum numbers between the isomeric and final states) and an yrast-trap (lower excitation energy of the isomer, which enables the decay to proceed only via high-multipolarity transitions). The most notable examples are the $K^{\pi}=16^{+}$ isomer ($T_{1/2}$=32 y) in ^{178}Hf and the $K^{\pi}=23/2^{-}$ isomer ($T_{1/2}$=160.44 d) in ^{177}Lu; these are also of interest for various applications, owing to their very long lifetimes.

At ANL, we have recently studied decays of the $K^{\pi}=23/2^{-}$ isomer ($T_{1/2}$=160.44 d) in ^{177}Lu by means of various Ge and scintillation detectors. The isomer was produced following neutron capture on ^{176}Lu (using natural lutetium material as a target) at the University of Massachusetts Lowell research reactor facility. The radioactive source was prepared at ANL following radiochemical separation of ^{177}Lu and ^{182}Ta radionuclide, the latter being produced from small tantalum impurities in the natural lutetium material. Singles measurements were carried out using high-purity Ge and LEPS detectors, as well as gamma-ray coincidence studies with Gammasphere. In addition, two $LaBr_3$(Ce) scintillation detectors were incorporated in the Gammasphere array. These allowed gamma-ray coincidences and fast-timing measurements to be performed. The previously known decays of the $K^{\pi}=23/2^{-}$ isomer, via the 115-keV E3 transition to the $17/2^{+}$ member of the ground state band of ^{177}Lu and via a first forbidden β^{-} decay to a similar $K^{\pi}=23/2^{+}$ isomer in ^{177}Hf, were confirmed, with the corresponding gamma-ray intensities determined with better precision in the present work. Importantly, new high-multipolarity (M3, E4 and tentatively E5) decay branches were discovered, which allowed the transition strengths for such rare decay modes to be determined and compared with the limited data available in neighbouring nuclei.

Results from these studies will be presented. Applicability of $LaBr_3$(Ce) detectors, coupled to a large multi-detector Ge array, for studying short-lived isomeric states in transitional and well-deformed nuclei will be also discussed.

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