MEASUREMENT OF THE Zr-80 HALF-LIFE BY DELAYED GAMMA TAGGING

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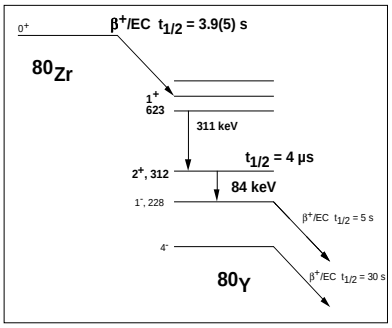
Nucleosynthesis of proton-rich nuclei with $56 \leq A \leq 100$ is thought to occur by rapid accumulation of protons on the heaviest nuclei of the Hot CNO cycle. The so-called rp-process, for rapid proton, breaks out of the Hot CNO cycle, producing heavier nuclei by successive proton additions and beta decays. The rate of proton capture is generally orders of magnitude larger than the β^+-decay; when the proton dripline is reached the process must wait for the last nuclide synthesized to β^+-decay or undergo di-proton capture. These nuclei, termed "waiting points", will hold all of the created material at any given time along the reaction pathway. Hence, they will determine the overall rate of the reaction process, and account for resulting nuclear abundances. The N = Z nuclei ^{68}Se, ^{72}Kr, ^{80}Zr, and ^{84}Mo are all such waiting points. Beta-decay half-life information for these nuclei is critical in astrophysical calculations to properly reproduce the reaction pathway and isotopic abundances.

Astrophysical calculations to simulate rp-process nucleosynthesis depend heavily on the properties of the involved nuclei. Limited experimental data is available; consequently input values are often approximated. Because of this parameter sensitivity and the importance of ^{80}Zr in the rp-process pathway, the ground state beta-decay was measured. Previous attempts to determine the half-life were unsuccessful due to production difficulties as the proton dripline is reached. However, recent advancements in the structural clarification of the daughter ^{80}Y have made this measurement possible. A $t_{1/2}$= 4(1) μs isomer in ^{80}Y was observed to decay via a single 84 keV transition.[7] Döring *et al*. suggest a 2^+ spin and parity for this isomer, making it the lowest positive-parity state in this nuclide.[8] Decay of ^{80}Zr is assumed to most heavily populate 1^+ levels in ^{80}Y; these levels will subsequently de-excite through electromagnetic transitions to the microsecond isomer.



Production of ^{80}Zr was accomplished via ^{24}Mg(^{58}Ni,2n)^{80}Zr, σ = 10 μb.[9] Reaction fragments were separated through the RMS and implanted onto the tape of a Moving Tape Collector. The tape was advanced at timed intervals to a position surrounded by Ge and scintillation detectors. Using Delayed Gamma Tagging (DGT), a time spectrum of delayed events with the 84 keV decay from the isomer gave the half-life of the parent Zr to be 4.1(5) s. Gamma-delayed coincidences revealed a 311 keV transition populating the 2^+ state, suggesting a 1^+ level at 623 keV in ^{80}Y, a value consistent with calculations reported by Döring *et al*.

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