Interpretation of metastable states in the $N > 70$ Zr region†

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An objective of the RIBF26 experiment was to investigate the deformed structures in the $A \gtrapprox 100$ Zr region. This region initially garnered interest through the discovery of the rapid onset of nuclear deformation from sphericity at $N = 60$, with some models predicting another shape transition at $N \approx 70$.[1,2)] In Ref. 3), decays of isomeric states of nuclei in this shape-change region were used to tentatively assign their deformations and single-particle structures.

Isomeric states were populated through the in-flight fission of a ^{238}U beam on a ^{9}Be target at 345 MeV/nucleon and intensity 6.24×10^{10} particles/s. Following identification, fission fragments were implanted into the WAS3ABi silicon detector and isomeric decays detected with the EURICA array of germanium detectors. Table 1 summarises the decays of the isomeric states observed. As well as identifying an isomeric state in ^{112}Nb for the first time, in some cases, the data provide an enhancement of statistics from previous observations.

Table 1. Summary of isotopes in which isomeric states were observed in this work. Given for each isotope are the number of detected ions in the particle identification plot, decay lifetimes of isomeric states, and the energy and relative intensities of the decay γ rays. The lower portion of the table are those nuclei relevant to the predicted $N \approx 70$ prolate-oblate transition region.

Isotope	Ions	τ [μs]	E_γ [keV]	I_γ
^{108}Nb	1.7×10^5	0.155(7)	62.3(4)	11(4)
			76.8(2)	100(10)
			88.1(2)	51(6)
			101.5(3)	18(3)
^{109}Nb	1.5×10^6	0.176(11)	116.5(3)	100(19)
			195.3(3)	94(18)
			312.2(3)	78(14)
^{113}Tc	5.4×10^3	0.53(11)	114.0(3)	–
^{117}Ru	1.8×10^4	3.28(10)	56.7(6)	4(2)
			81.8(2)	20(3)
			102.2(2)	23(3)
			126.8(3)	8(1)
			184.1(2)	100(8)
^{119}Ru	1.2×10^5	0.543(10)	90.3(2)	64(5)
			135.7(2)	100(7)
^{120}Rh	2.1×10^3	0.44(21)	97.6(4)	–
^{122}Rh	1.2×10^4	1.28(11)	64.0(3)	51(11)
			206.4(2)	100(14)
^{111}Zr	1.9×10^3	0.326(63)	265.8(3)	100(26)
			283.1(5)	30(13)
^{112}Nb	1.2×10^5	0.094(26)	44.2(3)	–
^{113}Nb	1.6×10^4	0.846(80)	135.4(2)	–
^{115}Mo	2.3×10^4	63(4)	93.7(3)	7(1)
			187.8(2)	100(7)
			198.6(3)	7(1)

Comparison of observations in ^{111}Zr, ^{112,113}Nb, and ^{115}Mo, which span the predicted prolate-oblate transition region, to potential-energy surface calculations provided tentative assignment to shapes and configurations of ground and excited states. The inferences suggest that both ground and isomeric states in ^{111}Zr are prolate deformed, whilst ^{112,113}Nb and ^{115}Mo are suggested to have oblate isomeric and ground states.

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