GAMMA-RAY SPECTROSCOPY IN THE VICINITY OF ^{108}Zr*

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The half-lives of 2_1^+ states were measured for ^{102,104}Zr and ^{106,108}Mo to test a new implementation of a $LaBr_3$(Ce) array at the RIBF, RIKEN, Japan. The nuclei of interest were produced through the fission of a

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345 MeV/nucleon ^{238}U beam and selected by the BigRIPS separator. Fission fragments were implanted into the WAS3ABi active stopper, surrounding which, 18 $LaBr_3$(Ce) detectors provided fast γ-ray detection. Timing between the $LaBr_3$(Ce) array and plastic scintillators allowed for the measurement of half-lives of low-lying states. The preliminary results, which agree with literature values, are presented along with experimental details.

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1. Introduction

The $A \sim 100$, $Z \sim 40$ region of the nuclear chart has long been known for its sudden onset of static quadrupole deformation at $N \sim 60$ [1]. This was first ascribed to the neutron–proton interactions of the spatially-overlapping spin–orbit partner orbits, $\pi g_{7/2}$ and $\nu g_{9/2}$ [2]. However, more recent calculations [3] and g-factor [4] measurements have underlined the importance of core polarisation and the influence of the low-Ω $\nu h_{11/2}$ orbitals.

The complexity of the factors which drive deformation in the neutron-rich zirconium region require stringent testing. The reproduction of energy levels can provide some evidence that the wave-function employed in calculations is correct, however, observables, such as the reduced transition probabilities serve as a more robust test.

In these proceedings, we present the measurement of the known half-lives of the 2_1^+ states in ^{102,104}Zr and ^{106,108}Mo through β–γ spectroscopy. From these, the $B(\mathrm{E2}; 2_1^+ \rightarrow 0_{\mathrm{g.s.}}^+)$ values are computed.

2. Experimental set-up

A decay spectroscopy experiment was carried out at the RI Beam Factory (RIBF). The in-flight fission of a $^{238}U^{86+}$ primary beam of average intensity 6.24×10^{10} particles/s accelerated to an energy of 345 MeV/nucleon produced a secondary beam of neutron-rich nuclides. Fission fragments were selected by the BigRIPS spectrometer using the $B\rho$–ΔE–$B\rho$ method [5] and identified using TOF–$B\rho$–ΔE measurements [6].

The secondary beam was implanted into the WAS3ABi silicon array [7], which detected ion implantations and their subsequent β-decays. Precise timing of β-electron emission was achieved using plastic scintillators of 2 mm thickness and area 65×45 mm^2 installed upstream and downstream of WAS3ABi. An array of 18 $LaBr_3$(Ce) [8] detectors, as well as the EURICA [9] array, surrounded WAS3ABi for the purpose of measuring isomeric and β-delayed γ-rays. The photopeak efficiency of the $LaBr_3$(Ce) array at $\sim$ 150 keV was measured to be 4%.

3. Experimental results

Implanted fission fragments were correlated with their β-decays by requiring that the β-decay had to occur in the same pixel as an implanted ion within approximately five times the β-decay half-life of the implanted nuclide. The β-electron was required to be detected in one of the β-plastics. As an example, the γ-ray energy spectrum of ^{106}Mo is shown in the right panel of Fig. 1, the inset shows the background-subtracted time-difference, ΔT, spectrum of the $2_1^+ \rightarrow 0_{\text{g.s.}}^+$ transition (ΔT is the time between a signal in the β-plastics and a γ-ray detection in the $LaBr_3$(Ce) array).

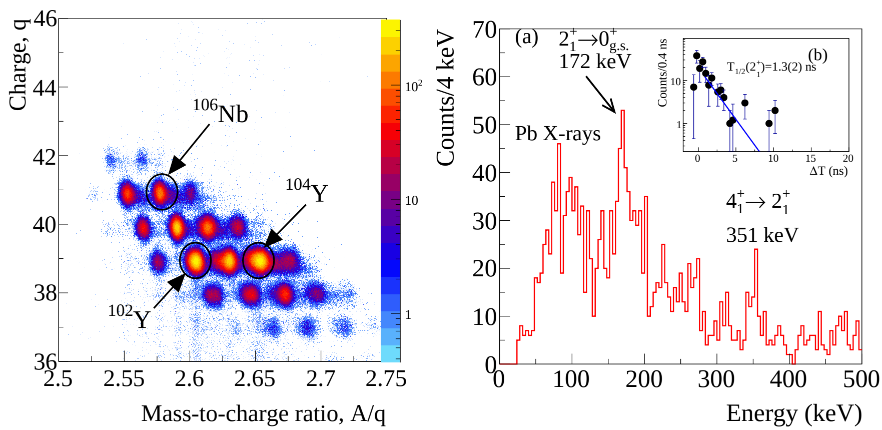

Fig. 1. Left: Particle identification plot with labels indicating the nuclides of interest. Right (a): Energy spectrum measured in the $LaBr_3$(Ce) array within 1 s of a β-decay correlated to an implantation of ^{106}Nb. (b): Background-subtracted ΔT projection of the $2_1^+ \rightarrow 0_{\text{g.s.}}^+$ transition, the curve (blue) is an exponential fit.

To extract the half-life of the 2_1^+ states for ^{104,106}Zr and ^{106,108}Mo, an exponential fit was carried out on the delayed shoulder of the ΔT spectrum between 2 and 15 ns. The results, presented in the left of Fig. 2 agree with adopted values [10, 11, 13, 14], with the exception of ^{102}Zr. This deviation is tentatively attributed to the influence of the half-life of a $K^\pi = 4^-$ state [12]. For the four nuclei under discussion, no delayed component was observed for the feeding $4_1^+ \rightarrow 2_1^+$ transitions. The right panel of Fig. 2 shows the $B(\text{E2}; 2_1^+ \rightarrow 0_{\text{g.s.}}^+)$ values obtained.

The presented method shall be extended to more neutron-rich isotopes in the region, to extend the knowledge of transition probabilities.

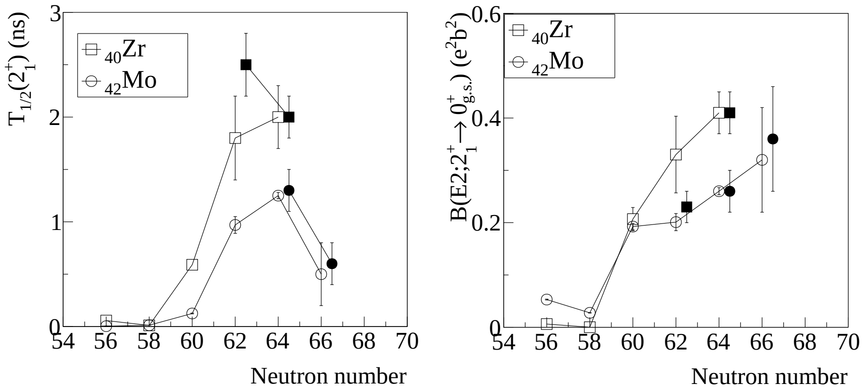

Fig. 2. Left: Half-lives of the 2_1^+ states as a function of neutron-number for Mo and Zr. Right: The corresponding $B(\mathrm{E2}; 2_1^+ \to 0_{\mathrm{g.s.}}^+)$ transition probabilities. In both, the solid symbols are values determined in this work, open symbols from Ref. [10, 11, 13, 14].

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