MEASUREMENTS OF PICOSECOND LIFETIMES IN THE TRANSITIONAL NUCLEUS ^{100}Pd USING THE RDDM IN INVERSE KINEMATICS* **

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Electromagnetic transition rates have been measured for decays from the ground state band in the transitional nucleus ^{100}Pd using the Recoil Distance Doppler Shift Method in inverse kinematics via the ^{24}Mg(^{80}Se,4n) ^{100}Pd reaction at a beam energy of 268 MeV. The nuclei produced were stopped using a Cu foil and data were recorded for 10 different target-stopper distances. The gamma-rays emitted were measured using the SPEEDY germanium detector array at WNSL Yale University and the target-to-stopper distances were determined and kept constant using the New Yale Plunger Device. The preliminary results of this study are presented.

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1. Introduction

Palladium isotopes with $A \sim 100$–110 demonstrate a quadrupole vibrational structure at low spins which evolves into a rotational structure at spins of $\sim 10\hbar$ [1]. The evolution of nuclear structure with increasing angular momentum is of general interest in this region, where the effect of populating high-j neutron $h_{\frac{11}{2}}$ orbitals has been noted to alter the collective excitations observed from a quasi-vibrational to near-rotational (*i.e.*, statically deformed) character [1]. At higher spins, the concept of anti-magnetic rotation has been proposed in ^{100}Pd [2]. This effect is characterised by a rotational-like energy sequence with small deformations and reducing $B(E2)$ values at higher spin values. This work describes an experiment to measure the $B(E2)$ values of the decays from the yrast transitions in ^{100}Pd up to spin $12\hbar$. Precision measurements of the $B(E2)$ values in the yrast sequence in ^{100}Pd are possible by using a fusion evaporation reaction in inverse kinematics resulting in a significantly increased recoil velocity compared to that reported in a recent, related study of this nucleus [3]. This has the potential advantage of allowing measurements of shorter-lived (higher spin) states in the yrast sequence.

2. Experimental details, data analysis and preliminary results

The nucleus of interest was created via the ^{24}Mg(^{80}Se,$4n$)^{100}Pd reaction at a beam energy of 268 MeV. The beam was provided by the WNSL Tandem Van de Graff accelerator at the Yale University and impinged upon a stretched ^{24}Mg target with a thickness 0.8 mg/cm^2. According to a prediction by the code PACE [4] the production cross-section of ^{100}Pd for this reaction is approximately 200 mb, which corresponds to $\sim 50\%$ of the total fusion cross-section. The recoils were stopped in a 16 mg/cm^2 thick Cu stopper. Gamma-rays emitted following the fusion evaporation reaction were detected using the SPEEDY [5] gamma-ray spectrometer which consisted of 10 germanium clover detectors, of which 4 each where positioned at 41.5° and 138.5° respectively with two further detectors placed at 90° with respect to the beam direction. The target and the stopper were mounted in the New Yale Plunger Device (NYPD) [6] and aligned parallel to each other. The data were collected for target-to-stopper distances at 35, 50, 62, 75, 100, 125, 150, 200, 250, 500 and 750 μm. The data were analysed using the Differential Decay Curve Method [7].

The majority of the analysis was performed using the *direct* gating technique, where a coincidence gate is set on the Doppler shifted component of the gamma-ray transition which directly feeds the state of interest, i. However, in some cases this was not possible due to contaminantion of the gating transition from other transitions with similar energies from other reaction channels and/or decay branches. In these cases, the *indirect* gating technique was used (see [8] for a discussion of this technique). The lifetimes in the case of the indirect and the direct gates based on the Differential Decay Curve Method [7] were extracted by using equations (1) and (2) respectively.

$$\tau_i(x) = \frac{\{C_\mathrm{s}, A_\mathrm{s}\}(x) - \alpha\{C_\mathrm{s}, B_\mathrm{u}\}(x)}{v\frac{d}{dx}\{C_\mathrm{s}, A_\mathrm{s}\}}\,, \qquad \alpha = \frac{\{C_\mathrm{s}, A_\mathrm{u}\} + \{C_\mathrm{s}, A_\mathrm{s}\}}{\{C_\mathrm{s}, B_\mathrm{u}\} + \{C_\mathrm{s}, B_\mathrm{s}\}}\,, \tag{1}$$

$$\tau_i(x) = \frac{\{B_\mathrm{s}, A_\mathrm{u}\}(x)}{v\frac{d}{dx}\{B_\mathrm{s}, A_\mathrm{s}\}}\,. \tag{2}$$

To determine the lifetime of the first 2^+ state at 665 keV, an indirect gate was placed on the backward shifted component of the $6^+ \rightarrow 4^+$ (773 keV) transition. The factors $\{C_\mathrm{s},A_\mathrm{u}\}$ and $\{C_\mathrm{s},A_\mathrm{s}\}$ correspond to the number of events of the unshifted and shifted components, respectively, of the depopulating $2^+ \rightarrow 0^+$transition in coincidence with the applied gate and samewise for the $\{C_\mathrm{s},B_\mathrm{u}\}$ and $\{C_\mathrm{s},B_\mathrm{s}\}$ in regard with the feeding transition. The lifetime was measured for both the backward and the forward projection.

Figure 1 shows sample gamma-ray spectra from the experiment gated on the backward shifted component of the yrast $6^+ \rightarrow 4^+$ transition in ^{100}Pd (associated with an unshifted energy of 773 keV). The analysis assumes a recoil velocity of $0.057(3)\frac{v}{c}$ which was calculated by measuring the energy differences between the stopped and shifted components of the same transitions in the yrast decay sequence of ^{100}Pd. The uncertainty in the $\frac{v}{c}$ measurement has been added in quadrature to the statistical uncertainty from the NAPATAU fits to give the final quoted uncertainty in the current measurement.

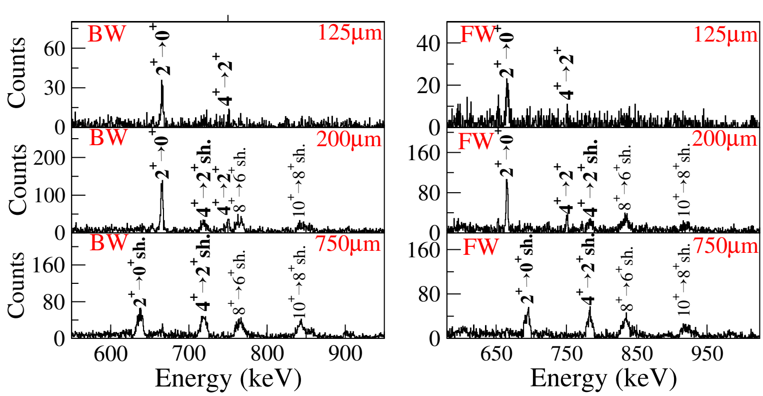

Fig. 1. Backward (left) and forward (right) projected spectra of the indirect gate on the backward shifted component of the $6^+ \rightarrow 4^+$ transition.

Figure 2 shows the (normalised) intensities of the shifted and unshifted components of the transition, shown in the middle and bottom panels respectively, and curves fitted to both. The curves fitted to the shifted components are a quadratic fit and the curves fitted to the unshifted components are the first derivative of the curves fitted to the shifted components. The lifetime is then extracted for each sensitive data point and the weighted average is given as the final result. This results in a value for the meanlife of $\tau = 13.3(9)$ ps for the first 2^+ state which is somewhat larger than the recently reported value by Radeck *et al.* for this transition of 9.0(4) ps [3]. The difference between the previous [3] and the present result on the lifetime of the 2^+ state is puzzling. Possible reasons are subject to speculation at this point.

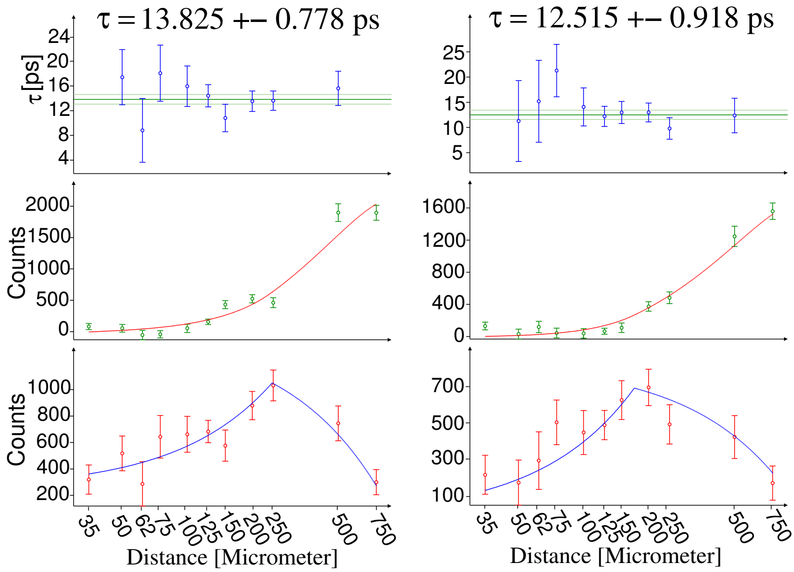

Fig. 2. Napatau plots [9] for the lifetime of the 2^+ state using the indirect gate on the backward shifted $6^+ \to 4^+$ (773 keV) transition and projecting backwards (left) and forwards (right), (see text for details).

3. Summary

The transition rates of the decays which make up the yrast sequence of the transitional nucleus ^{100}Pd have been measured using the RDDM in inverse kinematics. The experimental data from the current work allow measurement of the $B(E2)$ values for ^{100}Pd upto spin $12\hbar$ and a first analysis suggests a weakly deformed, transitional nucleus. The lifetime for the yrast 2^+ state in ^{100}Pd is deduced to be 13.3(9) ps, which corresponds to a $B(E2 : 2^+ \to 0^+)$ of 17.2(1.2) W.u.

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