FAST-TIMING MEASUREMENT IN ^{96}Pd: IMPROVED ACCURACY FOR THE LIFETIME OF THE 4_1^+ STATE*

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Direct lifetime measurements via γ–γ coincidences using the FATIMA fast-timing $LaBr_3$(Ce) array were performed for the excited states below previously reported isomers. In the $N = 50$ semi-magic ^{96}Pd nucleus, lifetimes below the $I^\pi = 8^+$ seniority isomer were addressed as a benchmark for further analysis. The results for the $I^\pi = 2^+$ and 4^+ states confirm the published values. Increased accuracy for the lifetime value was achieved for the 4^+ state.

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1. Introduction

In March 2020, the first experiment of the DEcay SPECtroscopy (DESPEC) setup [1] as part of the FAIR Phase-0 campaign was performed at the GSI Helmholtzzentrum für Schwerionenforschung. The focus of this experiment was the measurement of electromagnetic transition rates between excited states below known isomers using the fast-timing technique [2–5]. In particular, the main goal was an investigation of the decay of the 14^+, $T_{1/2} = 499(13)$ ns isomer in ^{94}Pd [5–8]. In the same experiment, lifetimes in several $N = 50$ isotones were studied for the first time [9, 10]. In addition, the known isomeric decay of the $I^\pi = 8^+$ state in ^{96}Pd was observed and used as a reference case for other lifetime measurements in order to verify the

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setup and the analysis method. Indeed, ^{96}Pd, with its four proton holes in the doubly-magic ^{100}Sn core, has proven to be attractive for nuclear structure studies in the last four decades [3, 11–13]. However, the lifetimes of the intermediate states below the isomer were reported only recently [12] and the conservation of the seniority quantum number was addressed. The last work indicated a seniority breakdown based in particular on the lifetime measurement of the 4^+ state, which, therefore, called for independent experimental verification.

2. Experimental details

The isomeric states in the nuclei of interest were produced by the fragmentation of a ^{124}Xe primary beam at 982 A MeV impinging on a 4 g/cm^2 thick ^{9}Be target [7]. The cocktail beam of secondary particles was analyzed in the FRagment Separator (FRS) [14]. Standard tracking detectors and separation methods were used to select and identify the species of interest on an event-by-event basis in terms of their mass-to-charge ratio (A/Q) and atomic number (Z).

Ions arriving at the final focal plane of the FRS were implanted in the Advanced Implantation Detector Array (AIDA) active stopper [15]. AIDA is situated in the center of the DESPEC setup in between two β-plastic scintillation detectors for fast β-decay time reference [1]. For registering γ-rays, 36 $LaBr_3$(Ce) detectors (FATIMA) [16] and 6 triple cluster HPGe detectors (GALILEO) [17, 18] were used surrounding the implantation setup. The FATIMA array served for fast-timing spectroscopy, while GALILEO provided precise energy information.

3. Data analysis

The specific isotopes of interest were unambiguously selected by gating on Z and A/Q obtained from the FRS, thus enabling the study of the delayed γ-ray transitions in ^{96}Pd (see Fig. 1). To determine the lifetimes of intermediate states populated in the decay of the 8^+ isomer, the E_γ–E_γ–Δt correlations were analyzed. Two methods were used to obtain the lifetimes of the 4^+ and 2^+ states: a fit of the exponential decay curve to the data, and the Generalized Centroid Difference Method (GCDM) [19].

As shown in Fig. 2 (a), the time difference distribution for the 684–1415 keV coincidence is symmetric, consistent with the expected short lifetime of the 2^+ state. Using the GCDM (Fig. 2 (b)), the upper limit of $T_{1/2} \leq 14$ ps was obtained after taking into account the PRD (Prompt Response Distribution) correction. Based on the small lifetime value of the 2^+ state, the 4^+ single experimental decay was fitted to the sum of time difference distributions for the 684 keV and 1415 keV transitions with re-

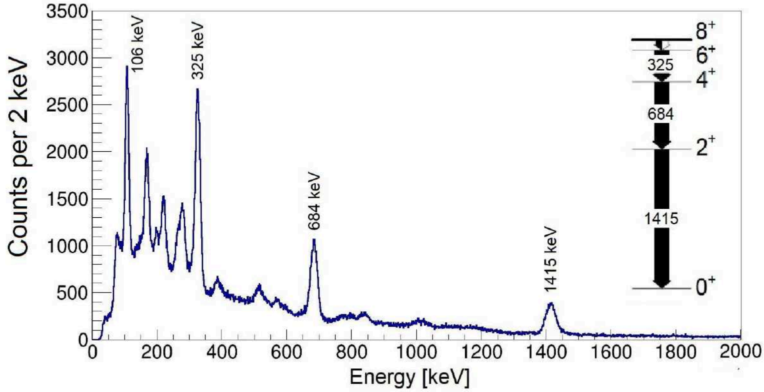

Fig. 1. Energy spectrum for isomer-delayed γ-rays obtained from FATIMA correlated to implantation of ^{96}Pd. The known transitions below the 8^+ isomer were labelled. The other peaks correspond to ^{139}La and ^{79,81}Br neutron-induced γ-rays and background lines. The inset shows the level scheme.

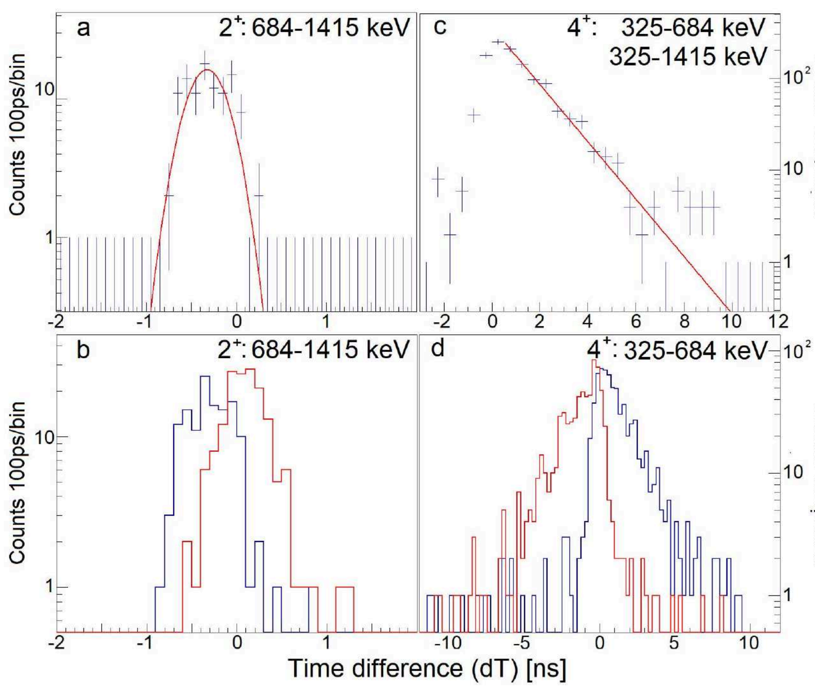

Fig. 2. (a), (c) Background-subtracted time difference distributions of γ-rays feeding and depopulating the 2^+ and 4^+ states, respectively. The spectrum for the 4^+ state is a sum of the distributions for two feeder-decay coincidences (see the text). (b), (d) Delayed and anti-delayed time distributions for the 2^+ and 4^+ states, respectively [19].

spect to the 325 keV feeder. The half-life of $T_{1/2} = 1.00(5)$ ns was obtained for the fit to the spectrum (Fig. 2 (c)) as well as for the GCDM method (Fig. 2 (d)). As preliminarily indicated by Jazrawi *et al.* [3], the obtained results are consistent with previously published data by Mach *et al.* (1.0(1) ns and $\leq$ 17 ps) [12]. Moreover, in the present analysis, the accuracy of the determined lifetime of the 4^+ state was increased.

4. Conclusion

The half-lives for the yrast 4^+ and 2^+ states of ^{96}Pd were measured using a single exponential decay fit to the data and the Generalized Centroid Difference Method. The obtained values are consistent with previously published data for these states. An increased accuracy was achieved for the lifetime of the 4^+ state.

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