Coulomb Excitation of ^{104}Pd by ^{32}S beam

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Introduction

Even-even stable Pd isotopes are of interest, as their low-energy level schemes were traditionally considered as the best examples of collective quadrupole-vibrational spectra. However, Coulomb excitation studies of $^{106-110}$Pd nuclei shows more complicated structure i.e. interplay of collective and single-particle effects [1, 2]. Low-energy 0^+ states in this isotopic chain may arise from collective excitation or are considered as intruder states [3].
In early eighties, Luontama et al. [4], also performed Coulomb excitation experiment of ^{104}Pd nuclei with very light beams of alpha and ^{16}O. As excitation pattern strongly depends on atomic number of collision partners, measurements with various beams are necessary to determine quadrupole shape parameters of the ground state and low-lying states. Moreover, ^{104}Pd targets are now a days often used in radioactive beams Coulomb excitation experiments [5, 6], therefore relatively accurate data is needed for the normalization of transition probabilities in radioactive nuclei excited on ^{104}Pd target. Low-lying energy states of even-even stable Pd-isotopes are shown in Figure-1.

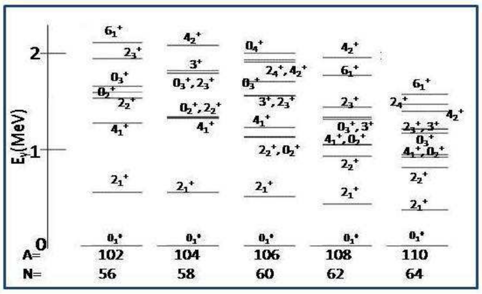

FIG. 1: Low-lying states in even-even stable Pd isotopes.

Experimental Details

The present experiment was carried out in March, 2015 using ^{32}S(14$^+$) beam at 91 MeV from the K=160 cyclotron at Heavy Ion Laboratory, University of Warsaw, Poland. Highly enriched ^{104}Pd target of 2 mg/cm^2 thickness was used with a dedicated Coulomb excitation setup of 15 HPGe detectors and 48 PIN-diodes. The scattered beam particles were detected by the PIN-diodes of 0.5 x 0.5 cm^2 active area, placed inside a small chamber (called as Munich chamber [7]) of 5 cm radius at ≈120-170 degree backward angles to the beam direction.
The de-exciting gamma rays were detected with EAGLE setup [8] of Germanium detectors having an energy resolution of about 2.5 keV. The total gamma-ray efficiency of the

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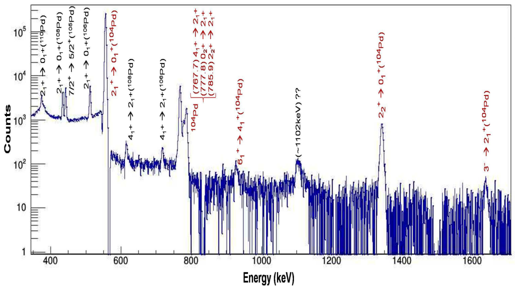

FIG. 2: Energy calibrated, Doppler corrected and random subtracted gamma-ray spectrum resulting from Coulomb excitation of highly enriched ^{104}Pd with 91 MeV ^{32}S.

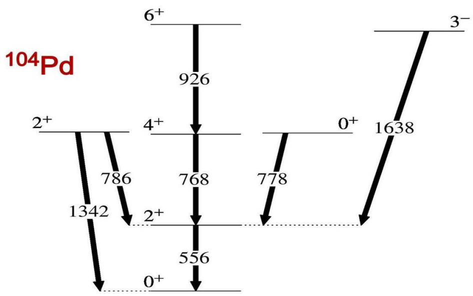

FIG. 3: Experimentally observed level scheme of ^{104}Pd.

EAGLE set-up for the present measurement was ≈25-30%. Individual energies and timing signals of HPGe-detectors were recorded for 5 days, in coincidence with the PIN-diodes signal.

Data Analysis and Results

The energy response of the HPGe detectors was calibrated by the use of ^{152}Eu source of known γ energies. Prompt and random timing gates were applied for each individual combinations of Germanium and PIN-diode detectors to filter the real events from the total raw spectrum. For the measured gamma-rays energies, a precise Doppler correction was performed based on the theta and phi angle information of decay γ-ray in-coincidence with the back-scattered particle. Higher excited states, $4_1{}^+$, $6_1{}^+$, $0_2{}^+$, $2_2{}^+$ and 3^- were also populated in ^{104}Pd along-with the first 2^+ state. Gamma transitions for other stable Pd isotopes were also observed as an isotopic contamination in the target, and are shown in Figure-2. Experimentally observed gamma-energies are shown in Figure-3. Since E2 transition rates are an unusually sensitive indication of the presence of collective motion, extensive and accurate information on these transition rates should provide a better understanding of the collective-model and shell-model aspects of these states. Statistics collected in this experiment was good enough to extract the static quadrupole moments and the transition probabilities for the low lying states. Further analysis of the experiment will be performed by using the least-squares fitting code GOSIA [9], and the final results will be presented.

Acknowledgments

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