Co-existance of AMR and collective rotation in ^{105}Pd

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The electric quadrupole transition rates for the high spin yrast states of $^{105-108}$Cd [1–4] and ^{110}Cd [5] show a characteristic drop with increasing angular momentum. This phenomenon has been associated with the antimagnetic rotation (AMR) based on numerical calculations within the framework of microscopic [6] or geometric models [7]. In addition, the non-yrast band of ^{107}Cd also originates due to AMR [3]. These facts indicate that the most favored mode of generation of high angular momentum states in Cd isotopes is AMR. Only recently this mode of excitation has been conclusively established in ^{104}Pd [8] thereby extending the domain of AMR to the A$\sim$100 region. This naturally induced us to investigate the other Pd isotopes through accurate lifetime measurements. In the present work we report the experimental data on ^{105}Pd.

The high spin states of ^{105}Pd were populated through ^{96}Zr(^{13}C, 4nγ)^{105}Pd reaction using the 63 MeV ^{13}C beam from the 14-UD Pelletron at TIFR, Mumbai. The target was made of 1 mg/cm^2 of enriched ^{96}Zr backed with 9 mg/cm^2 ^{206}Pb. The γ-rays were detected by using the Indian National Gamma Array (INGA) consisting of 18 Compton suppressed detectors. The analysis details of the γ-γ coincidence data can be found in Ref. [8].

The level scheme has been extended to $I^\pi = 55/2^+\hbar$ and three high spin bands have been identified. Two of these bands (band 1 and 2) are of positive parity and the other (band 3) is a negative parity band. Three angle-dependent γ-γ asymmetric matrices for the 40°, 90° and 157°

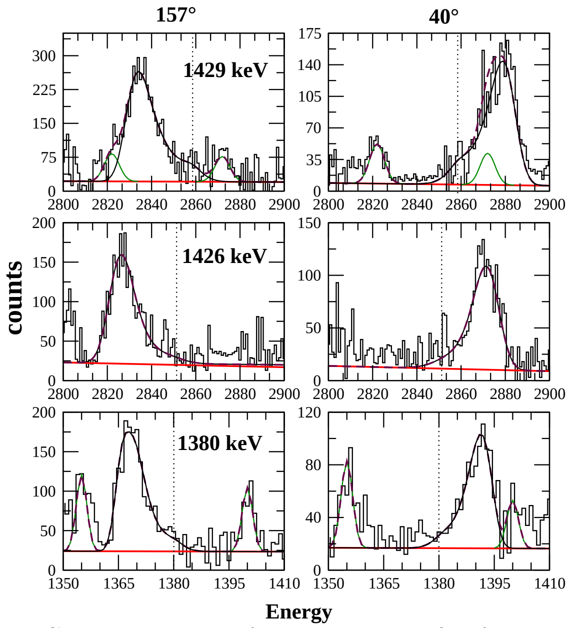

FIG. 1: Examples of the line shape fits for the topmost transitions of the three bands of ^{105}Pd.

angles were formed. These three matrices were used to extract the line shapes for the levels above $I = 23/2\ \hbar$. The theoretical line shapes were derived using the code LINESHAPE by Wells and Johnson [9]. A Monte Carlo simulation of the slowing down process of the recoiling nuclei in the target and the backing was used to generate the velocity profiles at the three angles of 40°, 90° and 157°. These profiles were obtained at a time interval of 0.001 ps for 5000 histories of energy losses at different depths of the target and its backing. The stopping powers formula with shell correction of Northcliffe and Schilling [10] was used for calculating these energy losses. The energies and intensities of the γ-transitions were treated as the input parameters to the lineshape

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fits. The sidefeeding intensities were fixed to reproduce the observed intensity pattern along the whole cascade for each band. The sidefeeding to each level has been modeled as a cascade of five transitions with a moment of inertia which is comparable to that of the band of interest. The quadrupole moments of the sidefeeding sequence were allowed to vary which when combined with the moment of inertia gave an effective sidefeeding time for each level. For each observed line shape, the in-band and the sidefeeding lifetimes and the intensities of the contaminant peaks, if present, were allowed to vary. For each set of parameters, the simulated lineshapes were fitted to the experimental spectrum using χ^2-minimization routine of MINUIT [10]. The uncertainties in the life time measurements were derived from the behavior of the χ^2 in the vicinity of the minimum for the simultaneous fit at the three angles. The other source of error in the level lifetime measurement was due to the uncertainty in the sidefeeding intensity which originated from the uncertainties in the intensities of the topfeeding and the feedout γ-transitions for the level of interest. This was estimated by finding the level lifetimes for the minimum and maximum values of sidefeeding intensities. The final statistical uncertainty was calculated by adding the uncertainties due to lineshape fitting and sidefeeding intensity in quadrature. However, it should be noted that this error does not include the systematic uncertainty which arises due to the choice of the stopping powers used for the present target-backing combination. This uncertainty has been found to vary between 5% to 15% by using the different stopping powers formulas in the line shape analysis. This uncertainty increases as a function of the spin since the shifted line shape becomes more pronounced with the decrease of level life time. Examples of the line shape fits for the topmost transition of each of the three bands have been shown in Fig 1. The extracted $B(E2)$ rates have been plotted in Fig. 2.

It may be observed from the figure that at high angular momenta, The $B(E2)$ values for the band 1 and band 2 drop smoothly while these values for the band 3 remain nearly constant. This observation conclusively establishes that the band 1 and 2 originate due to AMR while the band 3 originates due to the collective rotation. This is the first experimental evidence for the co-existence of the antimagnetic and the collective rotation in atomic nucleus.

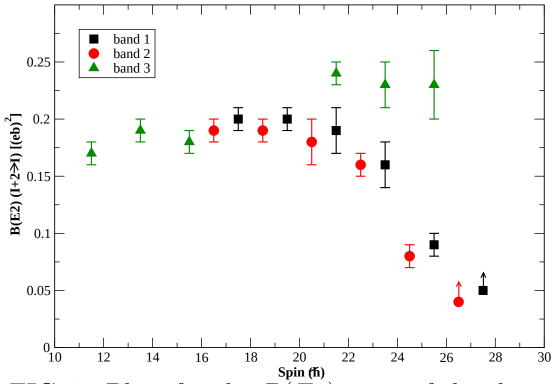

FIG. 2: Plots for the $B(E2)$ rates of the three bands of ^{105}Pd.

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