Antimagnetic Rotation in ^{101}Pd

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Introduction

The nuclei approaching the neutron and proton major shell closures at N=Z=50 provide a unique opportunity to study interplay between the single-particle and collective degrees of freedom, and influence of the valence orbitals on deformation. The proton particle-hole excitations across the major shell gap are energetically possible due to the strong proton-pair correlations and proton-neutron interaction between the spin-orbit partner orbitals [1]. For the nuclei approaching Z = 50 from below, the proton Fermi surface lies near the oblate-driving high-Ω orbitals of the intruder $\pi g_{9/2}$ subshell. Strongly prolate-driving low-Ω $\nu h_{11/2}$ subshell orbitals are accessible at low excitation energies for the nuclei receding the N = 50 shell closure. The delicate interplay of strongly shape-driving $\pi g_{9/2}$ and $\nu h_{11/2}$ orbitals can influence the overall shape of the nucleus, and result in γ-soft (triaxial) shapes with modest deformation $(\epsilon_2) \approx 0.15$ [2]. The relevant intringuing triaxiality based phenomena such as magnetic rotation [3] and degenrate twin bands have been reported in this mass region [4]. One of the novel feature which has been observed in this region is antimagnetic rotation (AMR) bands around doubly magic nuclei [5], where two pairs of nucleons in a twin-shears configurations are aligned back to back. In AMR, the E2 crossover transitions are weak and is similar to normal rotational band. Lifetime measurements show a decrease in B(E2) values with increasing spin in AMR. In recently observed phenomenon, " Nuclear tidal wave " wherein the measured values B(E2) values increas linearly with increasing spin. For the nuclei in this mass-region, the negative-parity $h_{11/2}$ intruder and the normal parity $d_{5/2}$ neutron/proton orbitals with $\Delta l = 3$, $\Delta j = 3$, and $\Delta\pi = -1$, are near the Fermi surface. Interaction between such orbitals is expected to result in octupole correlations.

Experimental details

Excited states in the ^{101}Pd nucleus were populated in the ^{75}As(^{31}P, 2p3n)^{101}Pd fusion-evaporation reaction at E_{lab}= 125 MeV. The de-excitations were investigated through in-beam gamma-ray spectroscopic techniques. The ^{31}P beam was provided by the Pelletron-LINAC facility at TIFR, Mumbai. The ^{75}As target of thickness 2.8 mg/cm^2 was prepared by vacuum evaporation and rolled onto a 10 mg/cm^2 thick Pb backing. The recoiling nuclei in the excited states were stopped within the target and the de-exciting gamma-rays were detected using the Indian National Gamma Array (INGA) consisting of 21 Compton suppressed clover detectors. Two and higher fold clover coincidence events were recorded in a fast digital data aquisition system based on Pixie-16 modules of XIA LLC [6]. The data sorting routine "Multi pARameter time stamped based COincidence Search program (MARCOS)", developed at TIFR, sorts the time stamped data to generate E_γ-E_γ matrices and E_γ-E_γ-E_γ cubes compatible with Radware format. These data were used to develop the level scheme. For the application of DSAM [7], lineshapes were obtained from the background substracted spectra projected from the two matrices consisting of events in the 65^o or 115^o detectors along one axis and all other detectors along the second axis, respectively.

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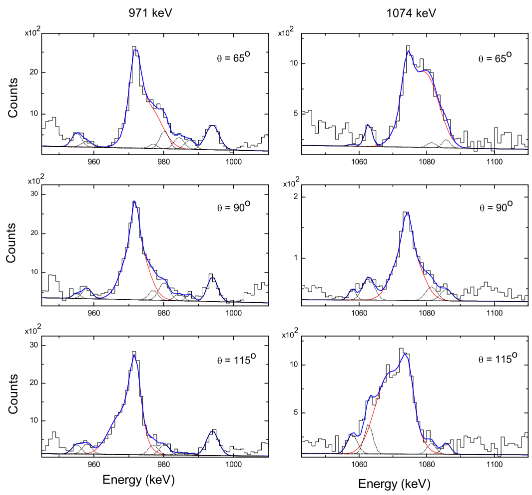

FIG. 1: Representative spectra and fitted lineshapes (solid lines) for the 971- and 1074 keV γ rays in the negative parity quadrupole band of ^{101}Pd. Dashed lines show contaminant peaks.

Lineshape Analysis

Lifetimes of the states of negative parity band of ^{101}Pd [8] were measured by DSAM. LINESHAPE [7] program was used for analysing lineshapes of transitions. The gating transitions, chosen for analysis, were below the transitions of interest. The program takes into account the energy loss of the beam through the target and the energy loss and angular straggling of recoils through the target and the backing. Shell-corrected Northcliffe and Schilling stopping powers were used for energy loss calculations. The value of time step and the number of recoil histories were 0.01ps and 5000, respectively. In the fitting procedure, the program obtains a χ^2 minimization of the fit for transition quadrupole moments (Q_t) for the transition of interest, transition quadrupole moments of the modeled side-feeding cascade Q_t (SF), the intensity of contaminant peaks in the region of interest, and the normalizing factor to normalize the intensity of the fitted transition. The best fit was obtaind through the least-square-minimization procedures SEEK, SIMPLEX, and MIGRAD [7].

The forward and backward Doppler-shifted lineshapes were observed for the 971-, 1074-, 1128- and 1422- keV transitions above the I $= 27/2^-$ state. The lineshapes of these transitions were obtained by putting gate on the 911 keV transition and are shown in Fig. 1. The side feeding into each level of the band was considered as a cascade of five transitions having a fixed moment of inertia comparable to that of the in-band sequences. The energies of γ-rays and side-feeding intensities have been used as input parameters for the lineshape analysis. The χ^2 minimization has been obtained using subroutine MINUIT [9].

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