Excited States 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. Various new deformation generating mechanisms have been identified in theoretical interpretation of the observed band structures. Investigations have revealed diversity in band structures resulting from coupling of the $g_{9/2}$, $d_{5/2}$, $g_{7/2}$, and $h_{11/2}$ valence nucleons and the core-excited configurations. 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]. 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. Indeed, octupole collectivity has been observed in the $_{54}$Xe, $_{55}$Cs, and $_{56}$Ba isotopes, where the proton orbital pair is responsible for octupole correlations.

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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 γ-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 acquisition system based on Pixie-16 modules of XIA LLC [5]. 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. The data were used to develop the level scheme of ^{101}Pd.

Results and Discussion

The present level scheme of ^{101}Pd is built on the $I^\pi = 5/2^+$ ground state and preserves the general basic features based on the γ-ray coincidence relationships in the previous established schemes [6, 7], which show mainly

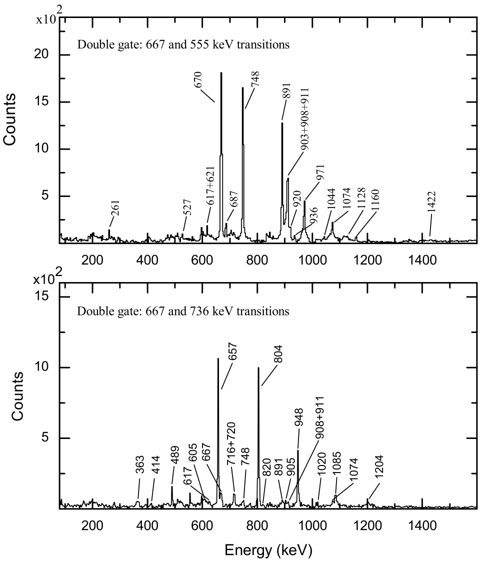

FIG. 1: γ-ray coincidence spectrum with double gate on 667-keV ($9/2^+ \rightarrow 5/2^+$) and 555-keV ($15/2^- \rightarrow 11/2^+$) , and 667-keV ($9/2^+ \rightarrow 5/2^+$) and 736-keV ($13/2^+ \rightarrow 9/2^+$) transitions. The unmarked peaks are contaminations.

the γ-ray transitions involved in the bands B1-B7. The level scheme is established up to ~ 15 MeV excitation energy and has been extended substantially with about 40 new transitions to the earlier reported ones. Various new transitions in these bands are shown in spectrum (Fig. 1). Band B3 built on the $\nu h_{11/2}$ orbital is the most intensely populated band in ^{101}Pd and band B1 based on the $\nu d_{5/2}$ orbital is the next intensely populated one in the present work and in the Suguwara work [6]. The earlier observed negative-parity band B5 with the lowest observed level at 3800 keV with $I^\pi = 23/2^-$ is established up to 11329 keV level with $I^\pi = 51/2^-$. A new cascade 1113-1206 keV of the E2 transitions is placed above the $39/2^-$ level in the B5 band. The $I^\pi = 23/2^-$ level is decaying through 543 and 617 kev M1 transitions, and 1160 E2 transition at $I^\pi = 19/2^-$ level in band B3. The new band head for this band is $I^\pi = 21/2^-$ level at 3257 keV. The intensities of transitions above the 6487 keV state are significantly reduced due to considerable absence of feeding from the band B5.

The excitation energy plot of band B7 lies $\sim$450 keV above the $\nu g_{7/2}$ band, as expected for the associated γ-vibrational band in this mass region. The band B7 built on the I = $17/2^+$ level at 2290 keV has been extended up to the I = $29/2^+$ level at 4993 keV. This band decays to the states of band B1 ($\nu d_{5/2}$) through the 363-keV, 617-keV and 1020-keV transitions. It also decays to the states of the band B2 ($\nu g_{7/2}$) through various new transitions. The low-lying positive-parity states in ^{101}Pd have contributions from the $\pi g_{9/2}$, $\nu d_{5/2}$, and $\nu g_{7/2}$ orbitals, which are near the respective Fermi surfaces. Deformed Hartree-Fock and angular-momentum projection (PHF) calculations were performed for the various configurations.

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References

[1] V. P. Janzen et al., Phys. Rev. Lett.**70**, 1065 (1993).

[2] W. Reviol et al., Nucl. Phys. A **557**, 391C (1993).

[3] D. G. Jenkins et al., Phys. Lett. B **428**, 23 (1998).

[4] P. Joshi et al., Phys. Rev. Lett. **98**, 102501 (2007).

[5] R. palit, et al., Nucl. Instrum. Methods A **90**, 680 (2012).

[6] M. Sugawara et al., Phys. Rev. C **86**, 034326 (2012).

[7] H.B. Zhou et al., Eur. Phys. J. A **47**, 47 (2011).