Rotational Band Structure in ^{101}Pd

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In the neutron-deficient nuclei approaching the neutron and proton major shell closures at N = Z = 50, experimental and theoretical investigations have revealed diversity in band structures resulting from coupling of the valence nucleons with different shape driving effects and the core-excited configurations. Various new phenomena have been identified, viz., smooth band termination (ST), magnetic rotation (MR) and antimagnetic rotation (AMR), wherein angular momentum is generated through gradual alignment of the valence proton hole and the neutron particle angular momenta with different initial geometrical compositions. These exhibit band structures with different magnitude and the trends of dynamic moment of inertia and the transition rates as a function of angular momentum. The AMR bands based on the $\pi g_{9/2}^{-m} \otimes \nu[(g_{7/2}/d_{5/2})^n(h_{11/2})^2]$ configurations have been observed in $^{105-108,110}$Cd with (m= 2, 4 and n = 1, 2) and ^{104}Pd with (m= 4 and n = 2) on the basis of lifetime measurements [1]. Exceptionally long vibrational band has been reported in ^{102}Pd, which exhibits sharp increasing trend of the B(E2) values with spin, and is indicative of angular momentum generation by increasing deformation. It has been explained as tidal wave travelling over the nuclear surface with constant angular velocity. In the present work we have provided some new experimental transitions on rotational band for ^{101}Pd, investigated using an advanced array of Compton-suppressed clover detectors. The lifetimes of states in the $\nu h_{11/2}$ band deduced from the present experiment are found to be considerably different from those reported recently by Sugawara *et al.* [2]. The results alongwith their interpretation for ^{101}Pd are discussed in [3]. The previously observed positive-parity band based on the $5/2^+$ ground state has been extended up to $I^\pi = (41/2)^+$ with addition of the 1297 keV and 1494 keV transitions. The rotational positive-parity band structure is interpreted in the framework of projected shell model calculations [4].

The PSM approach has been demonstrated to provide insight into structure of the high-spin states observed in medium and heavy mass nuclei. In this model, the deformed states are used as the basis states that provide an optimal basis set for investigating deformed nuclei. The spherical shell model is then diagonalised in the angular momentum projected basis to calculate the observable quantities. For odd-neutron systems, the PSM basis are composed of one-qp configuration and three-quasiparticle configurations, i.e.,

$$a^\dagger_\nu\,|\Phi>;\;\; a^\dagger_\nu a^\dagger_{\pi_i} a^\dagger_{\pi_j}\,|\Phi>; \qquad (1)$$

where $|\Phi>$ denote the qp vacuum $a^\dagger_\nu$ and $a^\dagger_\pi$ the qp creation operators, with the index ν (π) being the neutron (proton) quantum numbers. The above basis states are projected to good angular momentum states using the standard projection formalism [5–7]. The projected states are then used as the basis states to diaginalise the shell model Hamiltonian.

PSM calculations have been performed for ^{101}Pd by constructing the quasiparticle basis space with deformation parameters of $\varepsilon 2 = 0.180$ and $\varepsilon 4 = 0.020$. The axial deformation parameter has been adopted from the earlier studies [8]. The wavefunction amplitudes of the projected energies obtained for each intrinsic configuration are plotted in Fig. 1. This diagram referred to as the wavefunction diagram is quite intructive as it provides an insight into the structure of the observed band structures. The lowest band structure is obtained for the intrinsic state having, $K = 1/2$. This band structure, as expected, is having large signature splitting and for higher spin states. It is noted that unfavoured states are quite high in energy and for I=9/2, 13/2 and 17/2 and lowest energy for these states originate from the projection of one-quasiparticle state witn $K = 9/2$. What is most interesting to observe from Fig. 1 is that high-K 3-qp configurations cross the 1-qp configurations at $I = 21/2$. As the yrast configuration is expected to be

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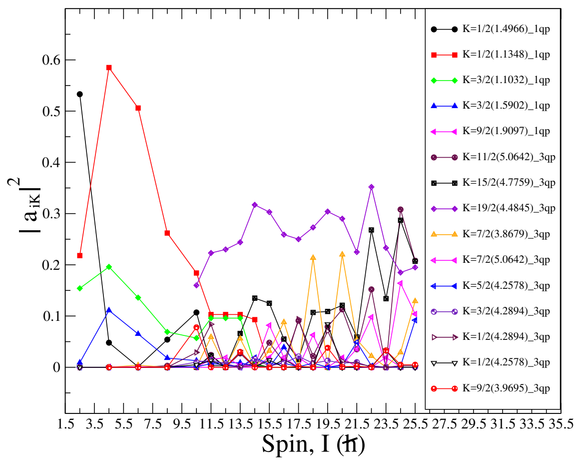

FIG. 1: Probability of various projected K-configurations in the wavefunctions of the yrast and the first excited bands for ^{101}Pd

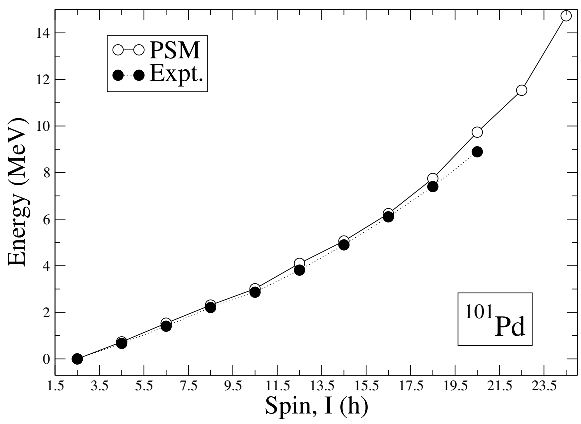

FIG. 2: Comparison of the calculated level energies for the positive parity bands with the present experimental data for ^{101}Pd.

dominated by $K = 1/2$ configuration, which is aligned towards the rotational axis, and with the high-K states that become yrast after the band crossing, suggests from the cranking model interpretation that there is crossing from principle axis to th tilted axis cranking. This implies that before I=21/2 transitions should be dominate by $E2$ decay, whereas afte the crossing, $M1$ transition should be predominant.

In the wavefunction diagram, Fig. 1, the band structures close to the yrast line are only depicted and in the actual analysis the projected band structures are calculated from all the states close to the Fermi surface within a window of about $(3MeV)$. This window results into around 50 intrinsic states from which angular momentum projection is performed. These projected states are then used as the basis states to diagonalise the shel model Hamiltonian. The energies obtained after the diagonalisation for the positive parity rotational band is depicted in Fig. 2 along with the known experimental data. PSM calculated energies in Fig. 2 has been plotted for only rotational band based on the wavefunction analysis. These wavefunctions for various bands are shown in Fig. 1 and it is evident from this Fig. 1 that rotational band upto I=23/2 result from the same intrinsic configuration of K=1/2 and 3/2 and are actually signature partner states. However, after the band crossing, the two bands have very different intrinsic structures and that is why they are labelled as two different bands. In the present abstract we have given only rotational Band PSM and Experimental calculations. The rotational band is dominated by the 1-qp configuration up to I = 19/2 and then 3-qp state with K=19/2 become important.

In Conclusion, It is expected that due to the dominance of high-K configurations after the crossing, $M1$ transitions should be the dominant mode of decay. Experimental data, indeed, does have a few dipole transitions above I=23/2 and more experimental work needs to be performed in order to probe further the predicted transition from PAC to TAC for ^{101}Pd.

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