Signature inversion in $K^{\pi}=1^{-}$:7/2[523]$_{\pi}\otimes$5/2[642]$_{\nu}$ band of ^{164}Tm

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Introduction

It is now well established that the Coriolis mixings plays vital role explaining the signature effects exhibited by deformed odd-odd nuclei [1-6]. The major objective of present calculations is the explanation of signature inversion observed in the $K^{\pi}=1^{-}$: 7/2[523]$_{\pi}\otimes$ 5/2[642]$_{\nu}$ band of ^{164}Tm, which could not be explained in earlier calculations by Reviol *et al*. [7].

Theoretical Framework

The theoretical formulation of Two Quasiparticle Plus Rotor Model (TQPRM) approach is well known and detailed description has been published elsewhere [1]. The total Hamiltonian in the frame work of TQPRM can be written as [1]:

$$H_{tot} = H_{\text{int}} + H_{rot}$$

where

$$H_{\text{int}} = H_{av} + H_{pair} + H_{vib} + V_{np}$$

$$H_{rot} = H^{o}_{rot} + H_{Cor} + H_{PPC} + H_{irrot}$$

The intrinsic part (H_{int}) of total Hamiltonian (H_{tot}) is constructed by the axially symmetric average field (H_{av}) plus various Hamiltonian operators corresponding to pairing (H_{pair}), vibrational (H_{vib}) and *n-p* (V_{np}) interactions. Similarly, the rotational part of total Hamiltonian consists of various terms such as pure rotation (H^{o}_{rot}), Coriolis coupling (H_{Cor}), particle-particle coupling (H_{PPC}) and irrotational component (H_{irrot}). The basis states used to solve the total Hamiltonian (H_{tot}) are:

$$\left|IMK\alpha\right\rangle = \sqrt{\left[\frac{2I+1}{16\pi^2\left(1+\delta_{K0}\right)}\right]} * \left[D^{I}_{MK}\left|K\alpha\right\rangle + \left(-1\right)^{I+K} D^{I}_{M-K} R_i \left|K\alpha\right\rangle\right]$$

The energy Eigen values are obtained by diagonalization of total Hamiltonian matrix in the $\left|IMK\alpha\right\rangle$ basis.

Selection of Parameters

Since the TQPRM formulation involves the mixing of various bands through first and higher order Coriolis mixing, so one has to construct a complete basis set of the interacting bands. Each two quasiparticle (2qp) band taking part in these calculations is characterized by three parameters namely, bandhead energy (E_{α}), inertia parameter $(\hbar/2\Im)$ and Newby shift energy (E_N). In order to estimate the band head energies of interacting bands taking part in the present Coriolis mixing calculations, we used formulation by Hoff [8]. The values of inertia parameter $(\hbar/2\Im)$ are extracted from the experimental data of neighboring nuclides [9] and the bands for which sufficient experimental data is not available to extract the inertia parameter, we adopted these values as 12.0 keV and 12.5 keV for the low and high-K bands respectively [10].

Result and Discussion

In the present paper, we present the TQPRM calculations for the explanations of signature inversion observed in the $K^{\pi}=1^{-}$:7/2[523]$_{\pi}\otimes$5/2[642]$_{\nu}$ band of ^{164}Tm, which could not be explained in earlier calculations by Reviol *et al.* [7]. The $K^{\pi}=1^{-}$ band exhibits signature inversion at $I=18^{-}$, with even and odd spin members favored, respectively before and after the point of inversion as shown in Fig. 1.

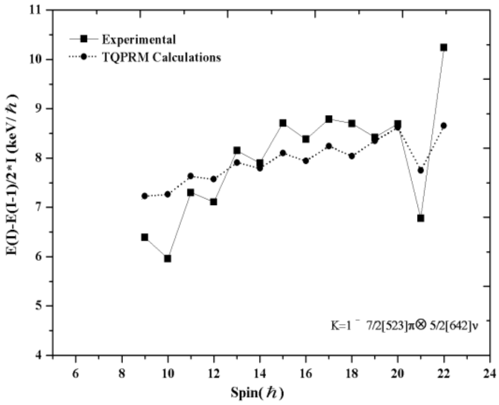

Fig. 1 Comparison among experimental and theoretical signature inversion observed in $K^\pi = 1^-$ band of ^{164}Tm nuclide [7].

Reviol *et al.* [7] successfully explain the observed signature splitting in the $K^\pi = 1^-$ band but they could not reproduce the change in the phase of oscillations after the point of inversion.

The single proton and neutron wave functions used in the present calculations are obtained using Nilsson Model [11] with deformation parameters as ε_2 = 0.250 and ε_4 = 0.013 [12] and potential strength parameters as k = 0.0620 and μ = 0.614 for protons and k = 0.0636 & μ = 0.393 for neutrons [9]. The basis space, comprising 40 bands appearing from the couplings of $h_{11/2}$ proton and $i_{13/2}$ neutron Nilsson orbitals, is considered in the present calculations and functional minimization subroutine is used in fitting procedure [13]. In Fig. 1, we present a comparison among experimental data and theoretical results obtained through the present TQPRM. From this figure, it is clear that the present calculations successfully reproduce phase of oscillations before and after the point of inversion, which could not be explained in earlier calculations [7]. In these calculations, we estimated the Newby shift energies as 47.0 keV and 22.5 keV respectively, for the $K^\pi=0^-$: $5/2^-[532]_\pi \otimes 5/2^+[642]_\nu$ and $K^\pi=0^-$: $7/2^-[523]_\pi \otimes 7/2^+[633]_\nu$ bands taking part in the present Coriolis mixing calculations.

On the basis of admixed set of wave functions calculated in the present results, we suggest that the Newby shifted $K^\pi = 0^-$: $7/2^-[523]_\pi \otimes 7/2^+[633]_\nu$ band plays vital role in explaining this experimentally observed change in the phase of oscillations after the point of inversion.

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