Coriolis Mixing in the K=0 and 1 rotational bands of $^{180\text{-}182}$Ta

Sushil Kumar[1], Sukhjeet Singh[1*], J. K. Sharma[1], A. Goel[2], Kawalpreet Kalra[2], A.K. Jain[3]
[1]*Department of Physics, Maharishi Markandeshwar University Mullana-133 207, INDIA.*
[2]*Department of Physics, Amity University Noida-201 303, INDIA.*
[3]*Department of Physics, Indian Institute of Technology, Roorkee-247667, INDIA*
** email: dhindsa_ss@yahoo.com*

Introduction

It is now well established that the Coriolis force plays an important role in influencing the complex spectra of deformed nuclei. However, the different possibilities of angular momentum coupling and their mixings further enhance the complexity of rotational spectrum of odd-odd nuclei. In the past, various Coriolis band mixing calculations in the framework of Two Quasi-Particle plus Rotor Model (TQPRM) have been carried out to high light the rotational structure of such nuclei [1, 2]. In the present paper, we investigate the role of Newby shift in explaining the observed signature splitting in two-quasiparticle bands of odd-odd ^{180,182}Ta nuclei. The mismatch about the placement of a 12^+ level in ^{180}Ta is also resolved.

Formulation

The theoretical formulation of TQPRM approach is well known and detailed descriptions have been published by several authors [2, 3]. The total Hamiltonian in the frame work of TQPRM can be written as:

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

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 is composed by 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:

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

The index $|K\alpha\rangle$ characterizes the configuration of odd neutron and odd proton. The symbols such as D^{I}_{MK} and R_i are Wigner functions and rotation operator respectively.

Result & Discussion

In the present paper, we present Coriolis band mixing calculations for two rotational bands observed in ^{180}Ta and ^{182}Ta nuclides. The point wise discussion of both the bands is given below:

^{180}Ta

The $\left(7/2[404]_{\pi} \otimes 9/2[624]_{\nu}\right) K = 1^{+}$ band of ^{180}Ta has been observed experimentally by several authors [4-6]. The main objectives behind these Coriolis mixing calculations for this nuclide are: (i) to explore the role of Newby shift in explaining signature effects observed in this band and (ii) fixing of level energy of 12^+ state to which there are different assignments by Dracoulis *et al.* [4,5] and Saitoh *et al.* [6]. Dracoulis *et al.* [4,5] assigned this level as 1774 keV decaying with tentative 337 keV gamma to 11^+, but Saitoh *et al.* [6] assigned this level as 1630 keV decaying with 195 keV gamma. The results of our Coriolis mixing calculations are consistent with Saitoh *et al.* [6], which suggests that the tentative 337 gamma placement from 12^+ to 11^+ by Dracoulis *et al.* [4,5] is not correct.

We also successfully reproduce the phase as well as magnitude of staggering observed in this band. The comparison among the theoretical calculations and experimental results is presented in Fig.1 (a). In order to explore the role of Newby shift in explaining this observed signature splitting, we present the TQPRM results with and without Newby shift in Fig.1 (a). From Fig. 1(a) it is clear that Newby shift plays a vital role in explaining the observed signature splitting. The value of the Newby shift pertaining to $K = 0$ band taking part in these calculations is 117.22 keV, which is greater than the earlier value (97.9 keV) reported by Goel *et al.* [7].We also suggest that the present value of Newby shift is a better estimate as compared to the earlier value reported by Goel *et al.* [7], because in earlier calculations authors could not reproduce the phase of staggering at few initial spins. Thus, present TQPRM calculations successfully explain the signature splitting observed in $K = 1^+$ band of ^{180}Ta and also strengthen the experimental results of Saitoh *et al.* [6] regarding the placement of 12^+ level in ^{180}Ta

^{182}Ta

The $7/2[404]_\pi \otimes 7/2[503]_\nu, K = 0^-$ band of ^{182}Ta has been observed by Van den *et.al.* [8]. This band exhibits pronounced staggering as shown in Fig. 1(b). In order to confirm the above said (as discussed for ^{180}Ta) role of Newby shift term in explaining the signature splitting in two-quasiparticle bands, we extended our TQPRM calculations to $K = 0^-$ band of ^{182}Ta. For these calculations, we constructed basis set comprising of all the $g_{7/2}$ proton and $h_{9/2}$ neutron orbitals. The value of the Newby shift for the $K = 0^-$ band taking part in these Coriolis mixing calculations is found to be -21.13 keV. The comparison of TQPRM calculations (with and without Newby shift term) along with experimental results is shown in Fig.1 (b). These results further confirm the role of the Newby shift in explaining the observed signature splitting in the $K = 0^-$ band of ^{182}Ta.

Conclusions

We have successfully reproduced the signature splitting exhibited by $K = 0^-$ and $K = 1^+$ bands observed in ^{180}Ta and ^{182}Ta using TQPRM calculations. The role of Newby shift in explaining this observed signature splitting is explored and an ambiguity about the placement of a 12^+ level in ^{180}Ta has been resolved.

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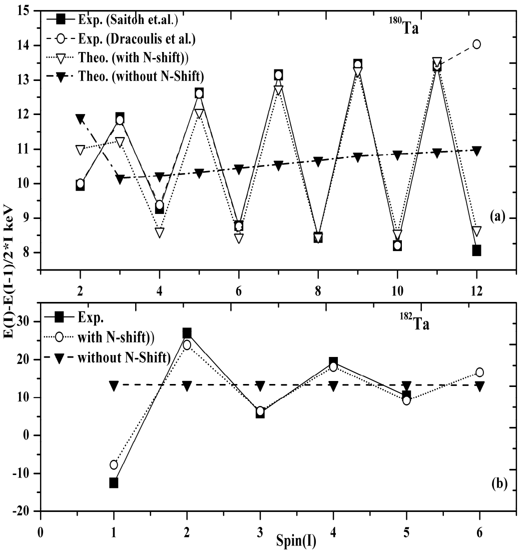

Figure 1(a-b): Comparison of experimental and calculated signature splitting of $K = 1^+$ and $K = 0^-$ bands.

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