Band Structure of ^{103,105}Tc

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Introduction

The nuclides with $40 \leq Z \leq 50$ and $N \geq 50$ are of current interest because of several shape transitions that occur in the A~ 100 mass region. Different types of deformation (e.g. prolate, oblate, triaxial) are observed in these nuclei and can coexist in the same nucleus in accordance with the underlying interplay between orbitals. For $Z \geq 44$, the active intruder orbitals are near the top of the $\pi g_{9/2}$ subshell, this drives shapes towards oblate deformation. On the contrary, when the neutron Fermi level lies below or near the bottom of the $\upsilon h_{11/2}$ sub-shell as for $N \geq 60$, the shape is driven to prolate deformation. In this region, the other neutron and proton states coming from the normal-parity sub-shells do not drive deformation very much, except the intruder $1/2^+[431]$ proton orbital originating from the $\pi(g_{7/2}/d_{5/2})$ sub-shells located above the Z = 50 major shell gap [1-4]. This orbital is expected to have strong deforming effect towards well-elongated shapes. In fact the first members of the rotational band built on this intruder state have been observed at moderate excitation energies in nuclei near the N = 66 neutron mid-shell. Therefore these nuclei are good laboratories to study the influence of orbitals on deformation. In the present work, the band structure and some other nuclear properties of ^{103,105}Tc have been studied in a microscopic frame work of calculations known as Projected Shell Model (PSM).

The Model

Since, in the present work, we have applied PSM to study the various nuclear structure properties of ^{103,105}Tc isotopes, so in this section, we present the basic input parameter used in the PSM calculations The detailed theory of PSM is available in a review article [5]. The total Hamiltonian employed in the present work is

$$\hat{H} = \hat{H}_o - \frac{\chi}{2}\sum_{\mu}\hat{Q}^{\dagger}_{\mu}\hat{Q}_{\mu} - G_M\hat{P}^{\dagger}\hat{P} - G_Q\sum_{\mu}\hat{P}^{\dagger}_{\mu}\hat{P}_{\mu}$$

where $\hat{H}_o$ is spherical single particle Hamiltonian. The second term in the Hamiltonian is the quadrupole-quadrupole interaction and the last two terms are the monopole and quadrupole pairing interactions, respectively.

The strength of the quadrupole force χ is adjusted in such a way that the known quadrupole deformation parameter ε_2 is obtained by the usual Hartree-BCS self-consistent procedure. The monopole pairing force constants G_M are adjusted to give the known energy gaps. In the present calculations, the monopole pairing strength is taken as

$$G_M = \left(G_1 \mp G_2\,\frac{N-Z}{A}\right)\frac{1}{A}\,(\mathrm{MeV})$$

where + (-) is for neutron (proton) while, in this work, G_1 and G_2 and are chosen as 19.70 and 10.0 MeV for both the Tc isotopes under study. The strength parameter G_Q for quadrupole pairing is assumed to be proportional to G_M where the proportionality constant is adjusted to reproduce the $g_{9/2}$ crossing at the right place.

Results and Discussions

In this work, the calculated yrast energy levels, band structure and the back bending for the ^{103}Tc and ^{105}Tc nuclei are presented. These results are displayed in Fig.1, 2 and 3 respectively along with their available experimental counterparts.

The basic conclusions drawn from the calculated results are as follows:

- The experimental yrast states are very well reproduced by PSM calculations.
- The intrinsic quasiparticle structure of ^{103,105}Tc shows that the lower energy yrast levels are arising from the one quasiparticle bands whereas the higher energy yrast levels are arising due to three quasiparticle bands.

- The theoretical results show back bending phenomenon in $^{103\text{-}105}$Tc where as this phenomenon is not been observed experimently.

On comparing PSM results with the experimentally available data, an overall good agreement has been found. The consistency of our data with the experiments shows the reliability of the applied theoretical model (PSM).

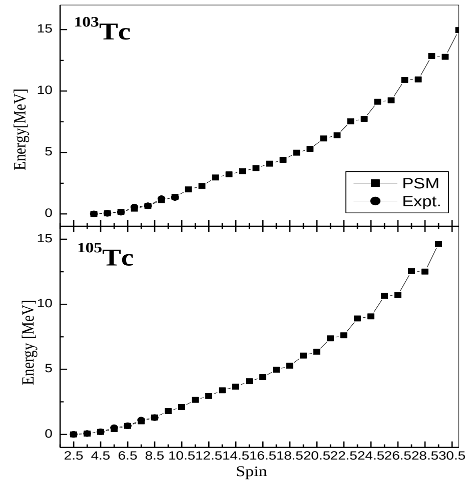

Fig. 1 Positive-parity yrast bands in $^{103,\,105}$Tc. Experimental data is taken from [6,7].

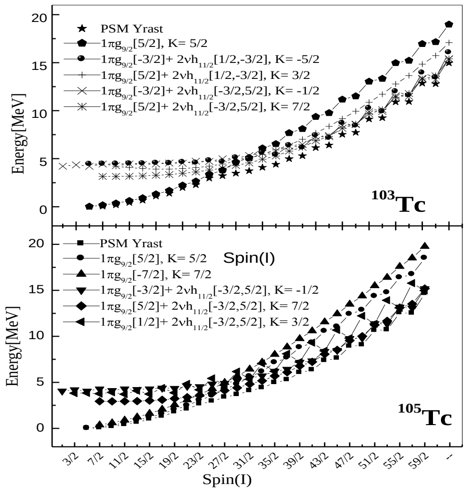

Fig. 2 Plots of Band diagrams for $^{103,\,105}$Tc

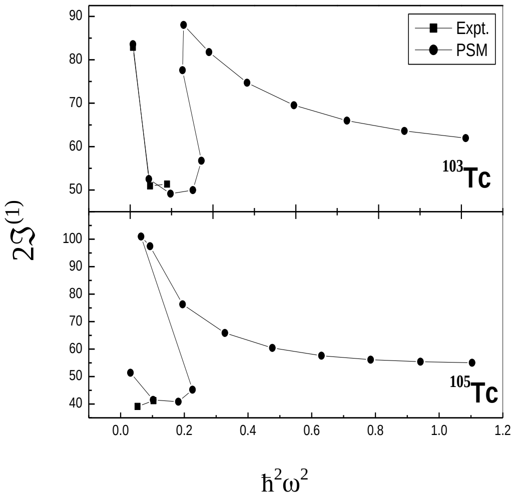

Fig. 3 Plots of Back bending for $^{103,\,105}$Tc

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