Band structure of ^{163}Tb isotope

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Introduction

The study of neutron rich nuclei in the mass region A~150 has been characterized by the interplay of collective motions and single-particle excitations. The nuclei lying in this mass region have proven to be fascinating due to the variety of structures resulting from the active proton orbitals and the softness of the nuclei with respect to deformation. Various high-spin phenomena have been investigated, for example, signature splitting and signature inversion [1,2], shape changes due to γ deformation [3,4], the persistence of proton pairing correlations at high spin [5], and band termination [6] in the nuclei of this mass region.

Thus, the nuclei in the mass region A~150 are good laboratories to study various nuclear structure phenomenon. The aim of the present work is to understand the high-spin rotational structure of ^{163}Tb isotope in the phenomenological theoretical framework known as Projected Shell Model (PSM).

Outline of the Framework

In PSM [7], the rotationally invariant Hamiltonian is taken to be

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

Where, H_o is spherical single particle Hamiltonian. The second term is the quadrupole-quadrupole interaction and the last two terms are the monopole and quadrupole pairing interactions, respectively. The monopole pairing strength G_M is given by

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

with ‘‘-’’ for neutrons and ‘‘+’’ for protons. Values of G_1 and G_2 are taken as 21.20 and 12.70 respectively. The quadrupole pairing strength G_Q is assumed to be proportional to G_M and the proportionality constant is fixed to be 0.16. In the present calculations, we use ε_2= 0.340 and the configuration space used consists of the three major shells for each kind of nucleon: N=3, 4 and 5 for protons and N= 4, 5 and 6 for neutrons.

Results and Discussion

In this work, the calculated yrast energy levels, band structure, transition energies and kinetic moment of inertia for ^{163}Tb nucleus are presented. These results are displayed in Figs.1, 2, 3 and 4, respectively, along with their available experimental counterparts.

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

a) The experimental yrast states are very well reproduced by PSM calculations (see Fig.1).

b) Bands structure for ^{163}Tb isotope has been obtained from the PSM calculations and is shown in the form of band diagram in Fig.2.

c) The variation of transition energy *(E(I)-E(I-1))* with spin is shown in Fig. 3. The presence of large staggering in the high spin region can be understand in term of band diagrams which clearly show that the yrast band at higher spins is formed by the mixing of two or more 3-qp bands and the interaction between these bands may result in large staggering at higher spins.

d) We have also studied the variation of kinetic moment of inertia with rotational frequency and the results are presented in Fig. 4.

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

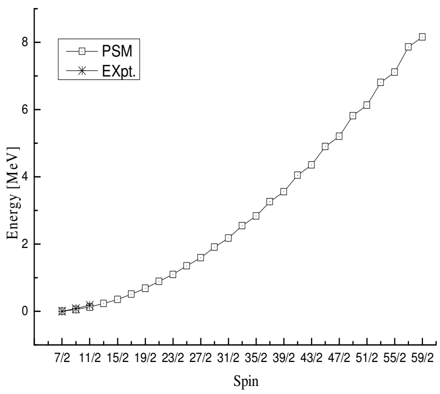

Fig. 1 Comparison of the experimental and calculated yrast spectra for ^{163}Tb.

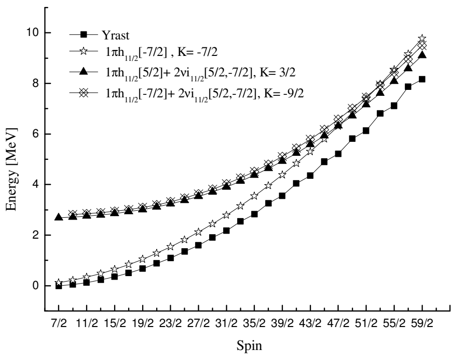

Fig. 2 Band diagrams for ^{163}Tb.

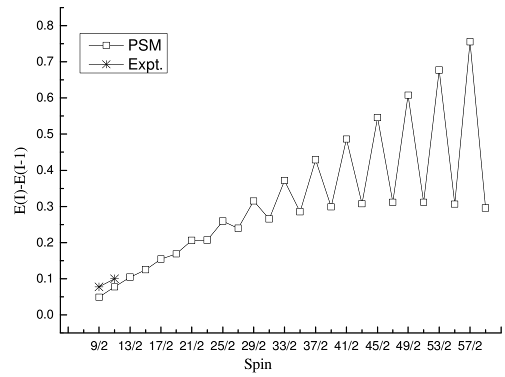

Fig. 3 Plots of transition energy (E(I)-E(I-1) versus spin for ^{163}Tb.

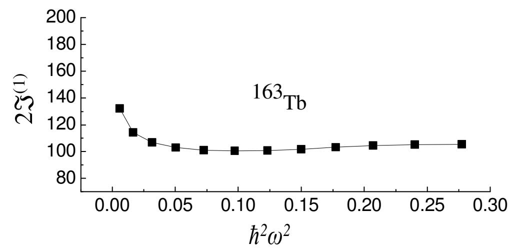

Fig. 4 Plots of twice the Kinetic Moment of inertia *i.e.,* $2\Im^{(1)}$ $(\hbar^2 MeV^{-1})$ versus square of rotational frequency $(\hbar\omega)^2$ for ^{163}Tb.

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