Study of ground state bands of neutron-rich $^{172\text{-}175}$Tm

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Introduction

Recently, the ground state bands of neutron-rich $^{173\text{-}175}$Tm isotopes have been studied by using deep inelastic and transfer reactions [1-3]. For example, the ground state band of ^{174}Tm is known up to spin $I^{\pi} = 13^{-}$ [3]. In case of odd-even ^{173,175}Tm, the ground state bands have been established up to spin $I^{\pi} = 23/2^{+}$.These isotopes are prolate deformed and typically have orbitals with large spin projection on the symmetry axis, Ω, near both the proton and neutron Fermi surfaces. This leads to many low-lying multi-quasiparticle states with high K occurring near the yrast line. The authors of ref. [2] have performed multi-quasiparticle calculations for ^{173,175}Tm. They have used single-particle energies from a Nilsson calculation and the Lipkin-Nogami formalism (plus pair blocking) for calculating pairing correlations. Their calculations have reproduced well the experimental energies.

In the present work, Projected Shell Model (PSM) [4] has been employed to study the ground state bands of neutron-rich $^{172\text{-}175}$Tm isotopes.

Brief Description of Theoretical Framework

In PSM, the shell model configuration is formed by carrying out the angular-momentum projection on the multi-quasiparticle states $\hat{P}^{I}_{MK}|\phi\rangle$,with $\hat{P}^{I}_{MK}$ being the angular momentum projection operator and $|\phi\rangle$ multi-quasiparticle states. The quasiparticle states are constructed from the solution of the deformed Nilsson Model followed by a BCS calculation. The multi-quasi particle states have been taken as proton-neutron quasiparticle pairs for odd-odd nuclei and one and three quasiparticle states for even-odd nuclei. The Hamiltonian that has been used in the present calculation contains the single particle energies, monopole pairing between like particles, quadrupole-quadrupole and quadrupole pairing interactions. The monopole pairing strengths G_M takes the form

$$G_{M} = \left[G_1 \mp G_2 \frac{N-Z}{A} \right] A^{-1}$$

where minus (plus) sign is for neutrons (protons) and G_1 and G_2 are adjusted to reproduce the pairing gaps in the mass 180 region. For ^{172,173,174}Tm, G_1 and G_2 are taken as 20.12 and 13.13 and for ^{175}Tm, G_1 and G_2 are taken as 20.42 and 13.13. The quadrupole pairing strength G_Q is assumed to be proportional to G_M with proportionality constant 0.18 for ^{172,174}Tm and 0.20 for ^{173,175}Tm.

Results and Discussion

The experimental energy levels of ground state bands in $^{172\text{-}175}$Tm are known up to spins 9^{-}, 13^{-} and $23/2^{+}$, respectively. The PSM calculations have been performed up to spins 14^{-}, $27/2^{+}$, 14^{-}, $27/2^{+}$ respectively. The quadrupole (ε_2) and hexadecupole (ε_4) parameters used in the present calculations are presented in Table 1.

Table 1: Deformation parameters used in present calculation.

Nuclei	^{172}Tm	^{173}Tm	^{174}Tm	^{175}Tm
ε_2	0.265	0.265	0.240	0.258
ε_4	0.043	0.067	0.073	0.080

In Fig.1, comparison of experimental and calculated energies of ground state bands is displayed. From Fig.1, it is seen that the calculated energies of ground state bands reproduce nicely the known experimental data in $^{173\text{-}175}$Tm. In case of ^{172}Tm, the low lying 2^{-} , 3^{-}

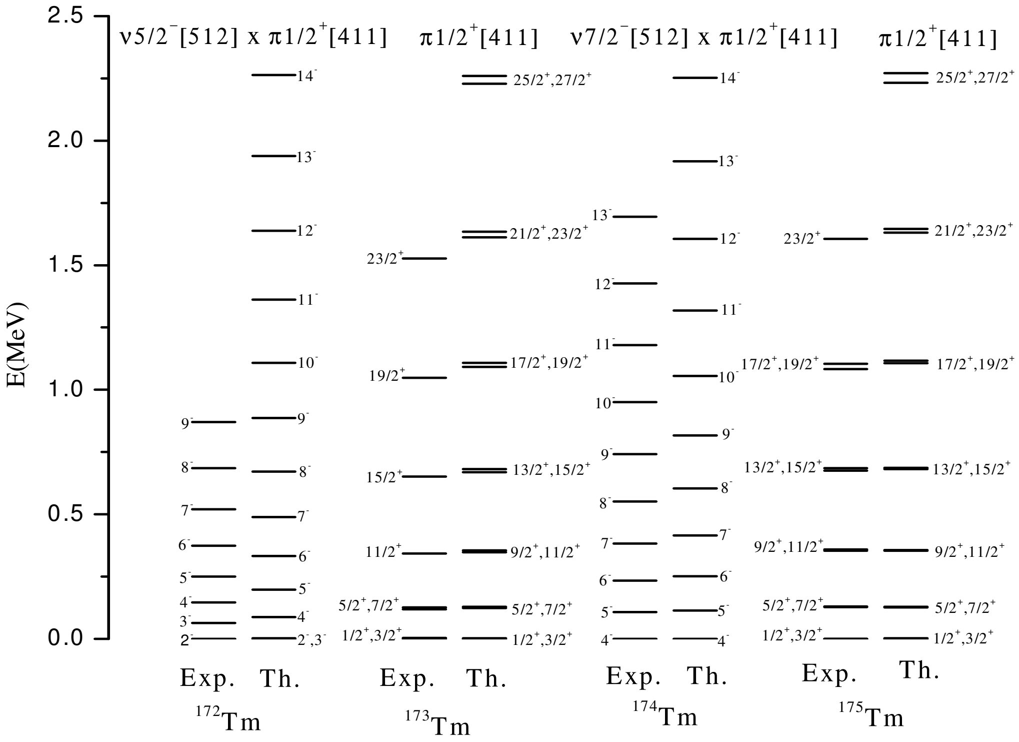

Fig.1 Comparison of calculated ground state energy levels with the available experimental data [1-3] in $^{172-175}$Tm.

and 4^- states are not reproduced by the present calculation. However, the band head spins and configurations assigned by the authors of refs. [1-3] are reproduced by the present calculation. The present calculation predicts that the ground state bands of ^{173,175}Tm arise from single quasiparticle state whereas in case of ^{172,174}Tm they arise from two quasiparticle states.

References

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