Theoretical interpretation of rotational bands of some neutron-rich odd-odd Ho isotopes

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Introduction

The advent of powerful instruments such as GASP in the recent decades has made it possible to extract experimental information about the high spin structure of very neutron-rich nuclei in the mass region A≈160. Many rotational bands have been reported in neutron-rich odd-odd nuclei [1,2]. The high spin states in neutron-rich odd-odd $^{160-164}$Ho isotopes have been investigated by means of in-beam γ-ray spectroscopy techniques using multi-detector array GASP [1,2]. The configurations of bands in $^{160-164}$Ho corresponds to the coupling of the low lying proton orbitals, such as $\pi 7/2^-[523]$ and the neutron orbitals, such as $\nu 5/2^+[642]$, $\nu 5/2^-[523]$, $\nu 3/2^-[521]$ and $\nu 11/2^-[505]$. The authors of refs. [1,2] have assigned configurations to the observed bands by analyzing the alignments, band crossing frequencies and electromagnetic properties of $^{160-164}$Ho isotopes in the cranked shell model (CSM) framework.

The aim of the present work is to interpret the observed rotational bands in odd-odd $^{160-164}$Ho in the Projected Shell Model (PSM) [3] framework.

Brief Description of Theoretical Framework

The Projected Shell Model (PSM) is a spherical shell model built over a deformed mean field plus BCS vacuum which incorporates the strong particle-hole and particle-particle correlations to quasiparticle (qp) states. For odd-odd nuclei, the ground-band is a two quasi-particle configuration and in order to describe the structure of well-deformed odd-odd nuclei, it is necessary to consider at least two qp configurations in the basis. 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 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 170 region. For $^{160-164}$Ho, G_1 and G_2 are taken as 20.12 and 13.13. The quadrupole pairing strength G_Q is assumed to be proportional to G_M with proportionality constant 0.14 for ^{160}Ho and 0.18 for $^{162-164}$Ho.

Results and Discussion

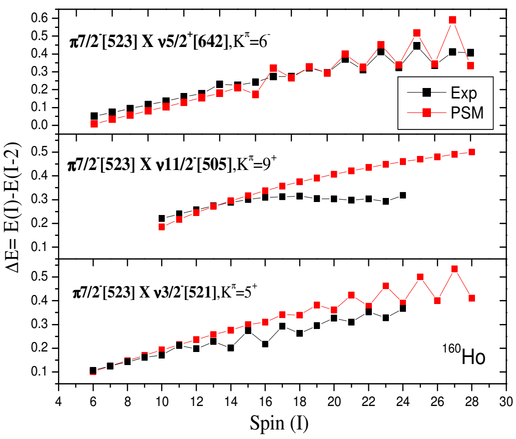
The quadrupole (ε_2) and hexadecupole (ε_4) parameters used in the present calculations are presented in Table 1.

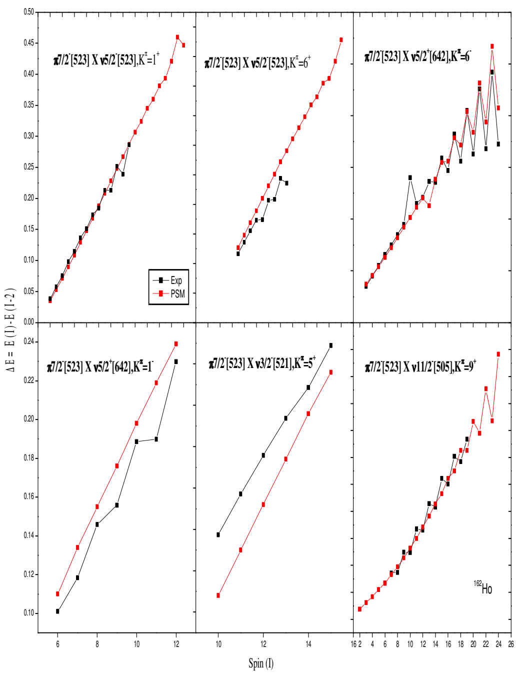
Table 1: Deformation parameters used in present calculation.

Nuclei	^{160}Ho	^{162}Ho	^{164}Ho
ε_2	0.260	0.277	0.280
ε_4	-0.015	-0.020	-0.022

In Fig.1, the calculated transition energies E(I)-E(I-2) of different bands of $^{160-164}$Ho isotopes are compared with experimental data. The configurations of the bands as assigned by

CSM are confirmed by the present calculations. From Fig. 1, it is seen that the transition energies of low-lying energy states of all the observed bands in $^{160-164}$Ho are reproduced well. However, the theoretical results of transition energies of some bands show deviation from the observed bands at higher spins. The deviation of the theoretical results from the experimental data at higher spins may be due to the meager contribution from neighbouring bands as the present calculations involves the mixing of many bands.





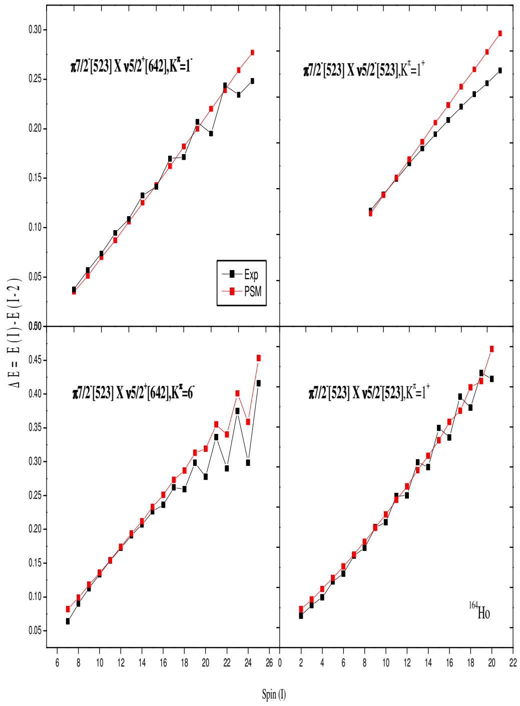


Fig.1 Comparison of experimental and theoretical transition energy E(I)-E(I-2) versus angular momentum I for $^{160-164}$Ho.

References

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