Study of deformed band spectra of odd mass neutron rich ^{153,155,157}Pm isotopes

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Introduction

In this paper, the systematic study of band structure of negative parity ground state bands of neutron rich ^{153,155,157}Pm isotopes are carried out. The theoretical results have been obtained for the band heads, energy levels and transition energies for ground state bands in these isotopes, which are compared with available experimental data. The shape transition from spherical to deformed region has been observed at the neutron number 90 in case of rare earth nuclei [1]. In the mass region A~150-160, nuclear deformation changes drastically, with only small change in mass number of isotopes. Recently, Bhattacharyya et al. [2] have obtained deformed band structures of neutron-rich $^{152-158}$Pm isotopes from the measurement of prompt γ rays of isotopically identified fragments produced in fission of ^{238}U+^{9}Be. In this work [2], the rotational band structures in odd-A Pm isotopes have been extended to higher spins. In these isotopes, the ground state bands are predominantly associated with the one quasiparticle (proton) configuration $1\pi 5/2^-[523]$ [2]. Therefore, it is of interest to determine the extent to which the present calculations can account for the ground state deformations of ^{153,155,157}Pm isotopes, in the mass region A~150-160.

Theory

A systematic and microscopic study of neutron rich and well deformed ^{153,155,157}Pm isotopes have been carried out by employing computer code [3] of projected shell model [4]. In the present study, three major harmonic oscillator shells with N=3,4,5 for protons and N=4,5,6 for neutrons are taken. 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.

$$\hat{H} = \hat{H}_0 - \frac{1}{2}\chi \sum_{\mu} \hat{Q}^{\dagger}_{2\mu}\hat{Q}_{2\mu} - G_M \hat{P}^{\dagger}\hat{P} - G_Q \sum_{\mu} \hat{P}^{\dagger}_{2\mu}\hat{P}_{2\mu}$$

The monopole pairing interaction constant G_M is adjusted via G_1 and G_2 and is taken as

$$G_M = \left[G_1 \pm G_2 \frac{N-Z}{A}\right] A^{-1}$$

where minus (plus) sign is for neutrons (protons). The pairing interaction strengths G_1 and G_2 are taken as 20.00 and 13.00 respectively, for calculation of ^{153,155,157}Pm isotopes. The quadrupole pairing strength G_Q is assumed to be proportional to G_M with proportionality constant 0.20 for all isotopes under study. The quadrupole (ε_2) and hexadecapole (ε_4) parameters used for the present calculations are 0.340 and -0.060 respectively, for all the isotopes ^{153,155,157}Pm.

Results and discussion

The present calculations are successful in reproducing the ground state band head energies of ^{153,155,157}Pm isotopes. From the comparison of calculated and experimental energy spectra of ground state bands (Figs. 1, 2 and 3), it is clear that there is good agreement between calculated and available experimental band spectra [2]. The dipole transition energies *[E(I)-E(I-1)]* of ground state bands in all these isotopes are also well reproduced. Further, the calculated transition energies *[E(I)-E(I-2)]* representing possible signatures ($\alpha = \pm 1/2$) in each isotope under study is also well reproduced (Fig. 4). The good agreement between the calculated data with the available experimental data lends strong support to the chosen valence space as well as to a correct choice of two-body interactions in nuclear structural calculations of these odd mass Pm isotopes. In summary, after performing angular momentum projection and configuration mixing calculations by employing the same quadrupole and hexadecapole deformation parameters for all the ^{153,155,157}Pm isotopes, we found that the obtained band head energies, energy levels as well transition energies between angular momentum states can reasonably explain the available experimental data within the framework of projected shell model.

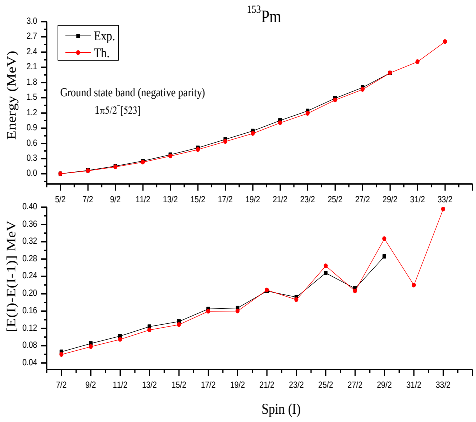

Fig.1 Comparison of experimental [2] and calculated (Th.) energy levels and dipole transition energies of ground state band of ^{153}Pm.

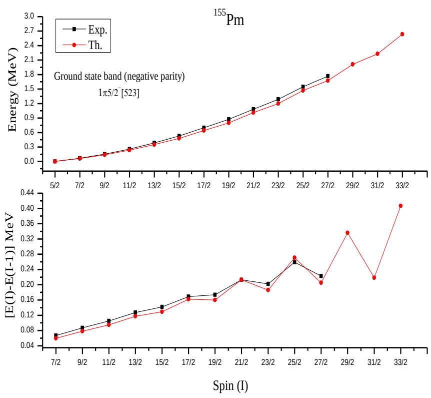

Fig.2 Figure caption is same as in Fig.1 except for ^{155}Pm.

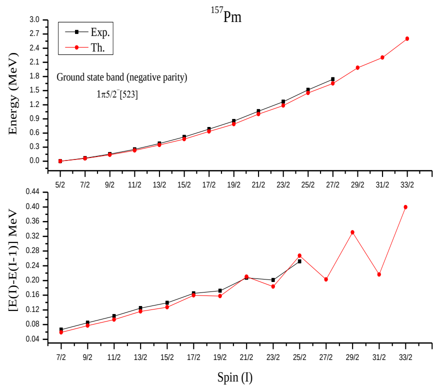

Fig.3 Comparison of experimental [2] and calculated (Th.) energy levels and dipole transition energies of ground state band of ^{157}Pm.

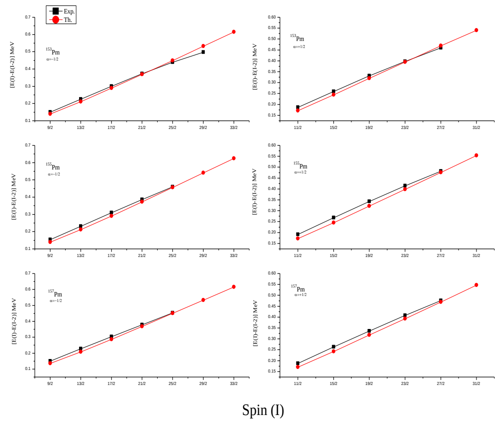

Fig.4 Comparison of calculated (Th.) and experimental (Exp.) transition energies of odd A Pm isotopes from N = 92 to 96. The different bands are marked by their signatutes (α).

References

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