Study of low-lying positive parity bands of ^{125}Cs

Barun Slathia[1],*Rani Devi[1], and S.K. Khosa[2]
[1]Department of Physics and Electronics, University of Jammu Jammu - 180006, INDIA
[2]Deptartment of Physics and Astronomical Science, Central University of Jammu, Jammu - 181143, INDIA
* email: rani_rakwal@yahoo.co.in

Introduction

The mass region A~125 exhibits many nuclear structure features. The study of nuclei that lie in this mass region is important both experimentally and theoretically. Very recently, Sun et al. [1] have reported on an experimental investigation of the odd-Z even N nucleus ^{125}Cs. They have studied the excited states in ^{125}Cs with the fusion-evaporation reaction ^{116}Cd (^{14}N,5n) at beam energy of 65 MeV by using the Nordball-multi detector system at the Niels Bohr Institute of Denmark. They have revised the band head excitation energies of the $h_{11/2}$ and $g_{9/2}$ bands determined in previous studies [2-5]. They have also identified two new bands for the first time. One of the new bands has been assigned the favored signature of the $\pi d_{5/2}[420]1/2^+$ configuration and another has been assigned the unfavored signature of $\pi g_{7/2}[422]3/2^+$ configuration at low spins. They have proposed the lowest $1/2^+$ and $3/2^+$ states in ^{125}Cs to be the band heads of $d_{5/2}[420]1/2^+$ and $g_{7/2}[422]3/2^+$ configurations, respectively.

The aim of the present work is to interpret the low-lying positive parity bands of ^{125}Cs in the Projected Shell Model (PSM) [6] framework.

Model

The projected shell model is a shell model truncated (Nilsson-type) in a single particle basis, in which the pairing correlations are incorporated into the basis by a BCS calculation for the Nilsson states. Angular momentum projection method is then used to restore the rotational symmetry violated in the deformed basis. Finally, the Nilsson Hamiltonian is diagonalized in the projected basis. The bogolyubov transformation is performed in order to take into account the static monopole force. The PSM calculation proceeds in two steps. In the first step, an optimum set of deformed basis is constructed from the standard Nilsson potential. The Nilsson parameters are taken from the ref. [7] and calculations are performed by considering the three major harmonic-oscillator shells (N=3,4,5) each for neutrons and protons. This defines the Nilsson + BCS quasiparticle basis. The intrinsic states within an energy window of 3.5 MeV around the Fermi surface are considered. This gives rise to the size of the basis states of the order of 36. In the second step, these basis states are projected to good angular-momentum states and the projected basis is then used to diagonalize the shell model Hamiltonian.

Results and Discussion

The values of quadrupole (ε_2) and hexadecapole (ε_4) deformation parameters which are employed in carrying out the present calculation are 0.220 and -0.050, respectively. The results have been obtained for the band head energies and transition energies of low lying positive parity bands of ^{125}Cs. The theoretical transition energies of the low-lying positive parity bands of ^{125}Cs along with the experimental data [1] are displayed in Figs. 1 and 2, respectively. From Fig. 1, it is clear that the transition energies (E(I)-E(I-2)) of Bands 2 and 3 of ref. [1] are closely reproduced up to the spin $21/2^+$ and $23/2^+$, there after the calculated results are found to be lower than the observed ones. However, for Band 1 and Band 4, the transition energies are in good agreement with the experimental ones. It was observed experimentally that at low spins there are interlinking dipole transitions E1 between band 2 and band 3 and eventually vanishes as one moves to the higher spin. However, at the upper part of Band 2 and 3, these transitions emerge again. In fig. 2, we have made a comparison of these interlinking dipole transitions E1 between band 2 and 3 with the theoretical results. In the upper part of the fig. 2 the experimental inter-band E1 transition energies of band 4 are compared with the theoretical results. It is seen from the figure that

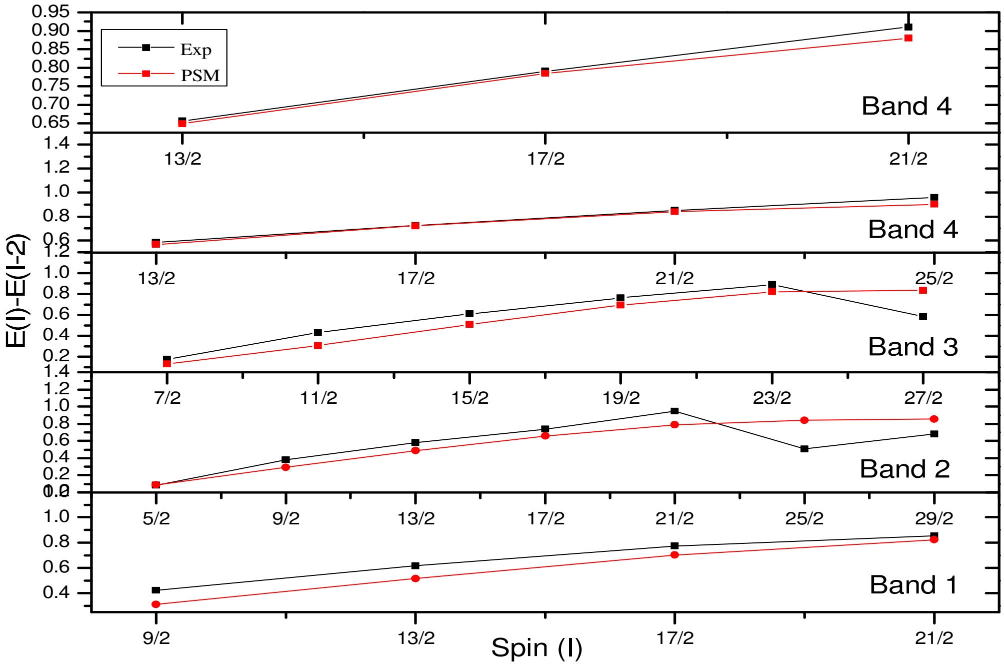

Fig.1 Comparison of experimental and theoretical transition energy E(I)-E(I-2) versus angular momentum I for ^{125}Cs

available experimental values are well reproduced by the present calculations for the Band 4. Experimentally, the band head of band 4 is located at an excitation energy of 563 keV, where as the present theoretical results for band 4 predict the band head energy of band 4 at 414 keV which is in reasonable agreement with the experiment. Besides, the band head energy of Band 1 is predicted to be 151 keV. Thus, the present calculation reproduces the band head spins, signatures of bands, configurations and band head energies of ref. [1] correctly.

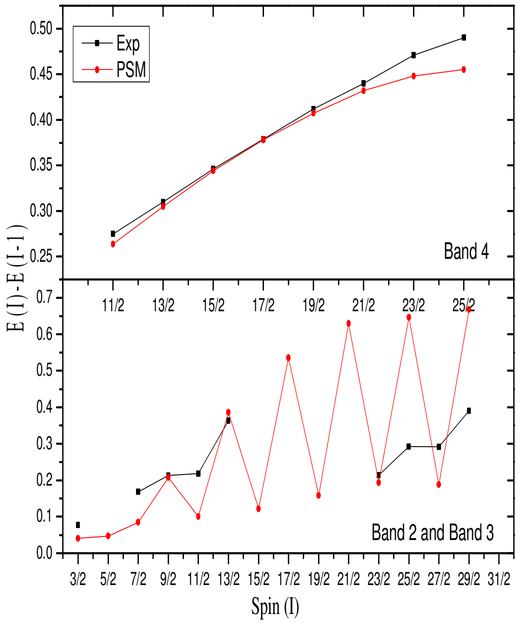

Fig.2 Comparison of experimental and theoretical transition energy E(I)-E(I-1) versus angular momentum I for ^{125}Cs.

References

[1] J. Sun et al., Phys. Rev. **C93**, 064301 (2016).

[2] U. Garg et al., Phys. Rev. **C19**, 217 (1979).

[3] J.R. Hughes et al., Phys. Rev. **C44**, 2390 (1991).

[4] M. Sugawara et al., Eur. Phys. J. **A2**, 237 (1998).

[5] K. Singh et al., Eur. Phys. J. **A27**, 321 (2006).

[6] K. Hara and Y. Sun, Int. J. Mod. Phys. **E4**, 637 (1995).

[7] S.G. Nilsson and C.F. Tsang, Nucl. Phys. **A131**, 1 (1969).