Theoretical study of band structures in odd-odd ^{168}Lu

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Introduction

The study of high spin states in odd-odd nuclei is interesting because of coupling of the odd neutron and odd proton to the deformed core and their possible interaction that are manifested in rich nuclear structure. The odd-odd nuclei provide a wealth of nuclear structure phenomena. The spectroscopic studies of odd-odd ^{168}Lu have been performed by various groups [1-2]. Recently, Roux et al., [3] have performed a detailed study of band structures in ^{168}Lu and extended previously known bands to high spins. Moreover, they have performed the Cranked Shell Model calculations to reconfirm the assigned configurations and also assigned configurations to newly identified bands. The nuclear structure of this isotope is interesting to study as multiple bands are known only in this odd-odd Lutetium isotope. Therefore, projected shell model (PSM) [4] has been employed to investigate the structure of negative parity bands in ^{168}Lu.

The Model

The PSM uses the deformed Nilsson model to produce deformed single-particle states, while BCS computations incorporate pairing correlations into this model. A collection of deformed quasiparticles (qp) was defined by the Nilsson+BCS. The current calculations make use of the major harmonic oscillator shells N=3,4 and 5 for protons and N=4,5 and 6 for neutrons. The Hamiltonian used in the present calculation is

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

The monopole pairing interaction G_M is taken as

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

where G_1 and G_2 are taken as 20.12 and 13.13, respectively. The quadrupole paring $G_Q = \gamma G_M$, where γ is the proportionality constant and is taken as 0.14 for present calculation.

Results and discussion

The present calculations have been performed by using quadrupole deformation parameter (ε_2)=0.30 and hexadecapole deformation parameter (ε_4)=0.027. In Fig. 1, the calculated energy levels are compared with experimental data. The negative parity bands labelled as 2 and 4 by ref. [3] are nicely reproduced by present calculations. The band head spin and configurations are consistent with the observed ones. The two quasi-particle band $1\pi 1h_{9/2}[1/2]+1i_{13/2}[5/2]$, K=3 is the yrast band in our calculations. The band head energy of this band is predicted to be 0.1525 MeV which is experimentally observed at 0.1921 MeV. The absolute difference between the two is 0.039 MeV. In Fig. 2, the band diagram comprising of low-lying negative parity bands is displayed. The weight factors which give the measure of the probability of the state having angular momentum (I) arising from the projected basis states show the dominant contribution of $1\pi 1h_{9/2}[1/2]+1i_{13/2}[5/2]$, K=3 band at low spins in yrast band. The weight factors of this band are greater than 0.357. The excited negative parity band has configuration $1\pi 1h_{11/2}[9/2]+1i_{13/2}[5/2]$, K=7 which is labeled as band 2 in ref. [3]. The weight factors of this band are in the 0.877-0.161.

Fig. 3, shows the comparison of calculated and experimentally observed transition energies *E(I)-E(I-2)* for two quasi particle $1\pi 1h_{9/2}[1/2]+1i_{13/2}[5/2]$, K=3 and $1\pi 1h_{9/2}[9/2]+1i_{13/2}[5/2]$, K=7 negative parity bands which are labelled as bands 4 and 2 by authors of ref. [3]. The observed *E(I)-E(I-2)* transition energy gaps are reproduced nicely by the present calculations.

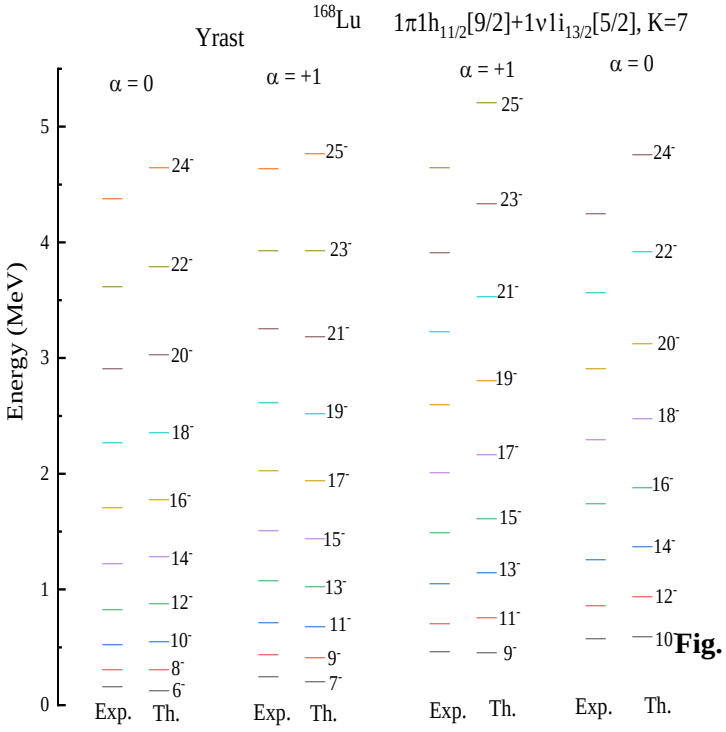

Fig. 1 Comparison of calculated energy levels with available experimental data [3] for negative parity bands of ^{168}Lu.

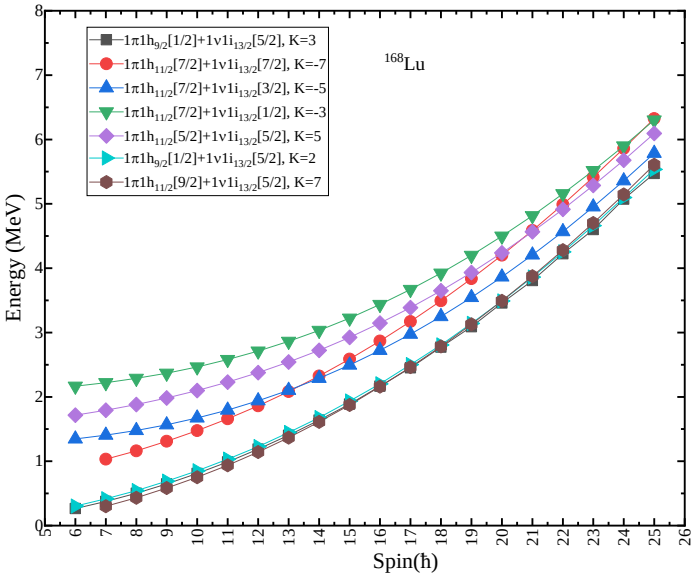

Fig. 2 Band diagram for negative parity bands of ^{168}Lu.

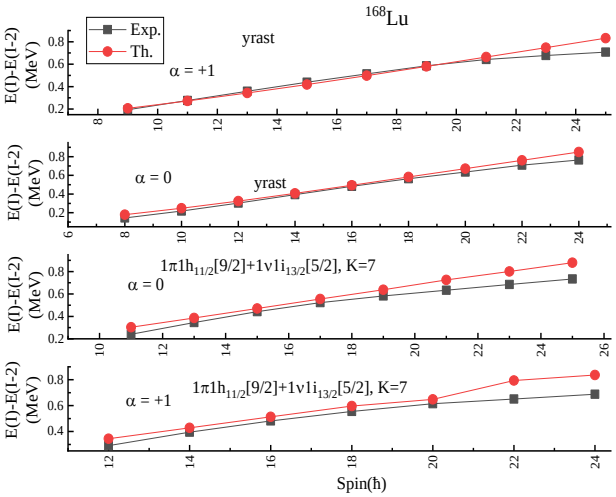

Fig. 3 Comparison of calculated transition energies *E(I)-E(I-2)* with available experimental data [3] for negative parity bands of ^{168}Lu.

Conclusions

The projected shell model with monopole pairing plus quadrupole-quadrupole interaction has been employed to study the low-lying negative parity band structures in ^{168}Lu. The observed excitation spectra and transition energies are nicely reproduced by the present calculations. The absolute energy difference for theoretical and experimentally observed I=25$^-$ state of yrast band is only 0.120 MeV.

Acknowledgements

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