Study of band structure of some odd proton Eu isotopes

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Introduction

Much work has been done on the odd-Z, odd-A nuclei in the rare earth region because of occurrence of fascinating variety of structures of nuclei in this mass region. The Eu nuclei are in the transitional deformation region and it provides an opportunity to investigate theoretically the deformation changes with mass number and excitation energy besides to study the structure of their excited states. The ^{153}Eu nucleus has been well studied over the last two decades [1-4]. The bands based on K = $5/2^+$; $5/2^-$ and $3/2^+$ are now known to high spins. For example ground state band of this nucleus is known up to $45/2^+$ [2]. The ^{155}Eu was extensively studied by different experimental techniques [5-8]. The experimental energy levels in this nucleus are known up to $29/2^+$ for the ground state band built on K=$5/2^+$. For excited negative and positive parity bands, energy levels are known up to spins $25/2^-$ and $23/2^+$, respectively. In these nuclei, the ground state bands are predominantly associated with the one quasi-particle (proton) configuration $\pi[413]5/2^+$. The first and second excited state bands are associated with the one quasi-particle (proton) configurations $\pi[532]5/2^-$ and $\pi[411]3/2^+$, respectively. The aim of the present work is to study in detail the band structure of some odd-Z nuclei.

Brief Description of Theoretical Framework

In the present work, Projected Shell Model [9] has been employed to study the ground state and excited bands of ^{153,155}Eu nuclei. 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. The monopole pairing strength G_M takes the form

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

where plus (minus) is for protons (neutrons) . G_1 and G_2 are adjusted to reproduce the pairing gaps in the mass region A≈150. For this nucleus G_1 and G_2 are taken as 20.00 and 13.12. The quadrupole pairing strength G_Q is assumed to be proportional to G_M with proportionality constant 0.25 for ^{153,155}Eu nuclei. The quadrupole(ε_2) and hexadecupole (ε_4) parameters used for the present calculations are 0.300 and 0.037 respectively for ^{153}Eu and 0.312 and 0.038 respectively for ^{155}Eu.

Results and Discussion

The results obtained for ^{153,155}Eu nuclei for the positive parity and negative parity bands are represented in figures 1,2. In Fig.1, the comparison of the observed band spectra of ^{153}Eu with the calculated band spectra is presented. From the comparison of the results, it may be noted that the energy states of positive parity ground state band with K = $5/2^+$, negative parity excited band with K = $5/2^-$ and positive parity excited band with K = $3/2^+$ are reasonably well reproduced with respect to their band head energies and energy difference between two successive levels. For the ground state band, the energy difference between observed and calculated values at the highest spins $45/2^+$ is 0.453 MeV. For the negative parity excited band, the energy difference between observed and calculated value at the highest available spin $45/2^-$ is 0.352 MeV and the difference between experimental and theoretical band head energies is 0.133 MeV. For the positive parity excited band, the energy difference between observed and calculated values at the highest available spin $29/2^+$ is 0.203 MeV and the difference between experimental and theoretical band head energies is 0.002 MeV. Hence a comparison of these results shows that the calculated band spectra are in agreement with the observed ones.

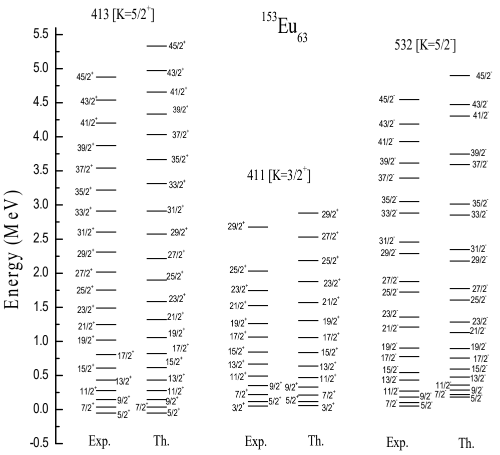

Fig.1 Comparison of experimental and calculated energy levels of rotational bands of ^{153}Eu.

In Fig.2, the comparison between experimental and calculated band spectra is presented for ^{155}Eu. The band with band head $K=5/2^+$ is the ground state band and the comparison of the results shows that it is reasonably well reproduced with respect to band head energies and relative energy difference. For this ground state band the energy difference between observed and calculated value at the highest available spin $29/2^+$ is 0.252 MeV. For the positive parity excited band built on $K=3/2^+$ the results indicate that at lower spins the agreement between experimental and calculated values of energy are not so good, but at higher spins the agreement between the two is good. For this positive parity excited band, the energy difference between observed and calculated value at the highest available spin $23/2^+$ is 0.015 MeV and the difference between experimental and theoretical band head energies is 0.128 MeV. For the negative parity band built on $K=5/2^-$ state, the difference in band head energies is 0.115 MeV, whereas the difference between the observed and calculated values at the highest available spin $25/2^-$ is 0.066 MeV.

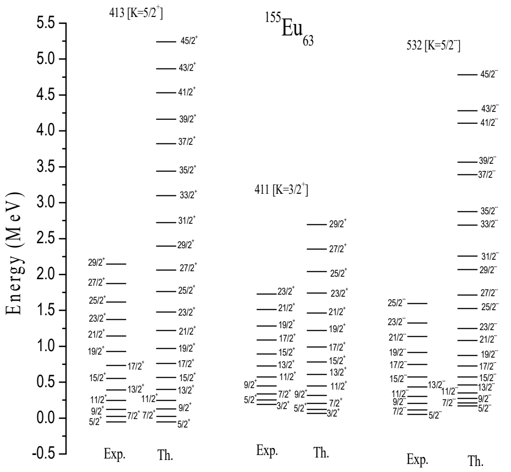

Fig.2 Comparison of experimental and calculated energy levels of rotational bands of ^{155}Eu.

References

[1] R. G. Helmer, Nucl. Data Sheets **107** 507 (2006).

[2] J. F. Smith et al. , Phys. Rev. **C 62**, 034312 (2000).

[3] J. F. Smith et al. , Phys. Rev. **C 58**, 3171 (1998).

[4] S. Basu et al. , Phys. Rev. **C 56**, 1756 (1996).

[5] P.T. Prokofjev et al. , Nucl. Phys. **A 455**, 1 (1986).

[6] R. Katajanheimo et al. , Z.Phys. **A 319**, 91 (1984).

[7] C.W. Reich, Nucl. Data Sheets **104**, 1 (2005).

[8] D.J. Hartley et al. , Phys. Rev. **C 57**, 2944 (1998).

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