Microscopic analysis of the γ band in ^{160}Dy

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Introduction

The Pairing-plus-Quadrupole model utilizing the cranked Hartree -Fock- Bogoliubov (CHFB) formalism has been extensively used to study the evolution of shape and other physical observables with increasing rotational frequency [1, 2]. The HFB optimization approach self-consistently determines the best shape as well as the optimal pairing correlations for each angular momentum as a cranking term is added to the Hamiltonian. Thus these calculations are most effective in reproducing the yrast bands in rotational nuclei. In the present work, we have applied this model to reproduce both the ground as well as the γ bands in ^{160}Dy.

The Model

The Pairing-plus-Quadrupole Hamiltonian of Baranger and Kumar [1] is used with the

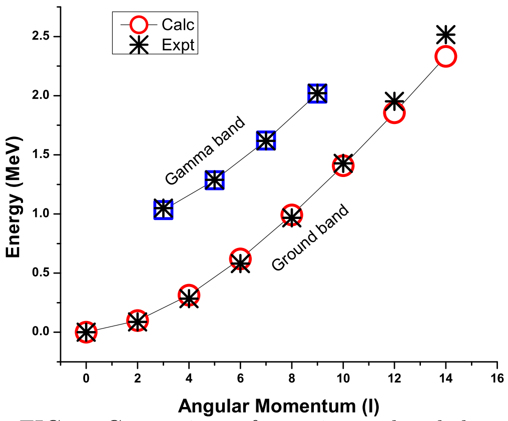

FIG. 1: Comparison of experimental and theoretical energies of ground and γ bands in ^{160}Dy .

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strength parameters suggested in Ref. [2]. Only the monopole pairing term is included in the Hamiltonian. No hexadecapole term has been included. The strengths of the residual interactions have been kept the same for both the ground and the γ bands. The other essential features of this model has been discussed in Ref. [2].

Parameter Choice

The oscillator shells N = 4 and 5 for protons and N = 5 and 6 for neutrons are used as the basis states. The inert core is taken as $^{110}Zr_{70}$ [2]. The strengths of the quadrupole and pairing residual interactions were obtained in Ref. [2] suitable for Sm (Z=62) to Yb (Z=70) isotopes, spanning a mass region from A = 152 to 174. These pairing and quadrupole force constants and the oscillator parameters are given by $G_p = 27/A$ MeV, $G_n = 22/A$ MeV, $\chi_2 = 70A^{1.4}$ MeV, $\hbar\omega_o = 41.2\ A^{-1/3}$ MeV. The set of spherical single-particte energies, which are capable of reproducing the observed spin dependence of g-factors from Sm to Os nuclei has been reported in Ref. [2]. A similar set of spherical single-particle energies has been calculated for A =160 using the mass dependence of μ and κ from the prescription of Nilsson et al. [3] as suggested in Ref. [2].

The Procedure

The ground band has been reproduced by minimizing the cranking Hamiltonian subject to the constraints of conservation of average particle number as well as angular momentum (I) with self-consistency conditions on pairing and quadrupole terms. The energy surfaces for J=3^+ state have been generated later as functions of the variations of axial and non-axial quadrupole deformation parameters, β_2 and γ, respectively. The γ deformation value has been chosen from these contours with the β_2 value close to the ground band, such that the experimental energy of the J=3^+ state of the γ band is reproduced reasonably well. The energies of other members (5^+, 7^+, 9^+) of the γ band have been calculated with that particular fixed choices of β_2 and γ, without any self-consistency check on the quadrupole terms.

Results and Discusssion

It has been already shown in Ref.[2] that the strengths of the pairing interactions chosen, reproduce the experimental odd-even mass differences for the isotopes under study. Similarly, the quadrupole interaction strengths reproduce the calculated ground-state deformation of the ground band deduced from experimental B(E2) values. Moreover, the g-factor variations which depend upon the detailed nature of relative alignment of neutrons and protons are also reproduced reasonably well with the present set of single particle energies. The comparison of the calculated energies of the ground band and the γ band with experimental data is shown in Fig. 1. Similarly, the calculated g-factors for both the bands are shown in Fig. 2. The experimental values of g-factors are available in literature only for the ground band. Thus the comparison with data is not shown in Fig.2.

The ground band

The energies of the ground band are reproduced reasonably well till I=14^+ (Fig.1). It is well-known that the variation of g-factors with increasing angular momentum is sensitive to the relative alignment of the proton and neutron spins. The calculated trend of g-factors for ^{160}Dy ground band reproduces the experimental data well [2]. The decrease in the g-factor values with increasing I is a clear indicator of neutron alignment (Fig.2). Ref. [2] only reports the comparison of the experimental and theoretical trends of g-factor variation for ^{160}Dy, instead of the absolute values. However, detailed analysis and comparison of the absolute values of calculated g-factors with data for the ground band are under progress.

The γ band

The energies of the γ band, till I=9^+, are reproduced extremely well with the γ deformation chosen to reproduce the I=3^+ energy (Fig.1). In contrast to the ground band, the g-factors of this band show an upward trend indicating proton alignment (Fig. 2).

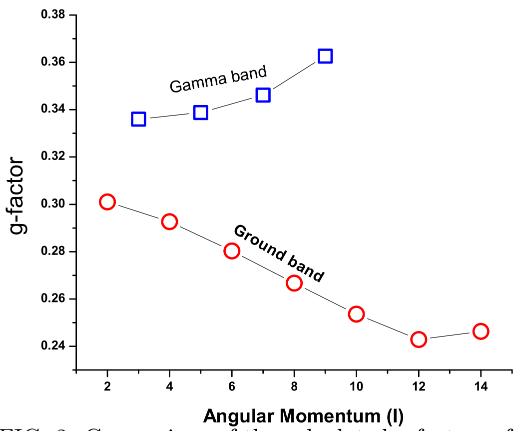

FIG. 2: Comparison of the calculated g-factors of the ground and the γ bands in ^{160}Dy .

Summary and Conclusion

The experimental features of the γ-band have been reproduced reasonably well within the CHFB formalism. The features of this band have been compared with the ground band. The g-factors predicted for the γ band indicate proton alignment manifested through the upward trend in contrast to the downward trend shown for the ground band members. A detailed microscopic analysis is under process to understand the origin of the contrasting features of these two bands.

References

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