The study of ^{152}Gd and ^{154}Dy isotopes in the frame work of interacting boson model and SU(5) symmetry

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Introduction

The Interacting Boson Model (IBM), initially introduced by Arima and Iachello has been rather successful in describing the collective properties of several medium and heavy nuclei [1-5]. In the first approximation, only pairs with angular momentum L=0 (called s-boson) and L=2 (called d-boson) are considered. This model has associated with it an inherent group structure [1]. In spite of simplicity it is capable of providing a beautiful theoretical explanation of the observed spectra exhibited by many nuclei.

In the recent years, several systematic studies of even-even nuclei have been performed within the framework of the IBM model [2-4]. Lipas [7] studied the properties of the g-, β- and γ-bands, of the $^{150-160}$Gd isotopes and correlated the two models viz., IBM-1 of Arima and Iachello [1] and projection model (PM) of Lipas and co-workers [7] in terms of few parameters. In the present age the low-lying energy spectra of the $^{148-154}$Sm, $^{150-156}$Dy, ^{158}Er and ^{160}Yb isotopes were well established[8] for the g-, β-, γ- and multi-phonon bands. It would be interesting to see the results of the study of a series of $^{152-158}$Gd and $^{154-160}$Dy isotopes while by taking into account the nucleus to nucleus dependent interacting boson-boson approximation Hamiltonian of IBM-1.

Method and Calculation

The IBM-1 model in its group theoretical formulation, exhibits three dynamical symmetries, each corresponding to a particular way of breaking the degeneracy of the parent U(6) group. One of these is the SU(5) symmetry, which arises from the group chain decomposition

$$U(6) \longrightarrow \begin{cases} SU(5) \supset O(5) \supset O(3) \supset O(2) \ (I) \\ SU(3) \supset O(3) \supset O(2) \qquad\quad (II) \\ O(6) \supset O(5) \supset O(3) \supset O(2) \quad (III) \end{cases}$$

In ^{152}Gd and ^{154}Dy isotopes only the ground band are known and the energy ratio is 2.1 to 2.2, respectively. These isotopes lie close to the SU(5) limit of the IBM-1. The parameter ϵ and c_4, c_2 and c_0 are calculated using,

$$\epsilon = E(2_1^+)$$

and

$$c_4 = E(4_1^+) - 2E(2_1^+) = \alpha + 8\gamma \qquad (1)$$
$$c_2 = E(2_2^+) - 2E(2_1^+) = \alpha - 6\gamma \qquad (2)$$
$$c_0 = E(0_1^+) - 2E(2_1^+) = \alpha + 10\beta - 12\gamma \quad (3)$$

where

$$a = \frac{1}{8}(4\epsilon - 3c_4), \quad b = \frac{c_4}{8}.$$

The calculated spectrum of the ^{152}Gd and ^{154}Dy isotopes for g-, β- and γ-bands are compared with experimental and IBM-1 calculations in Fig.1 and Fig.2.

The ^{152}Gd Isotope

The $R_{4/2}$ ratios of the ^{152}Gd and ^{154}Dy are 2.0-2.2. The 4_1^+ level is nearer to 0_1^+ state. It indicates that ^{152}Gd and ^{154}Dy nucleus lie nearer to SU(5) limit of IBM-1. The initial values of the ϵ, c_0, c_2 and c_4 parameters (Eq.1-4) are calculated using the energies of 2_1^+, 4_1^+,

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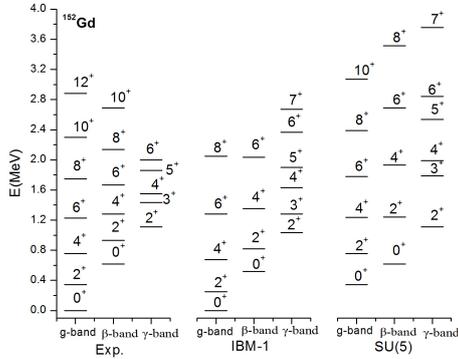*Electronic address: `vidyathakur@yahoo.co.in`

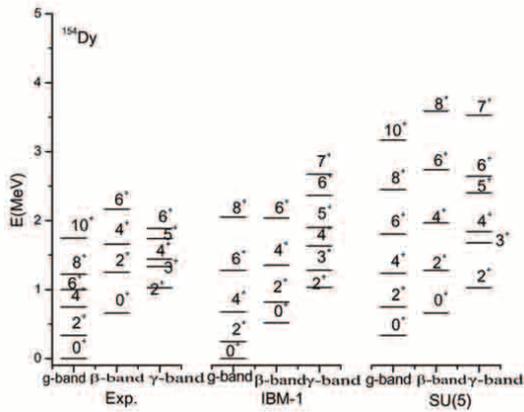FIG. 1: The calculated spectrum of ^{152}Gd isotope by IBM-1 and SU(5) limit are compared with the experiment.

FIG. 2: The calculated spectrum of ^{154}Dy isotope by IBM-1 and SU(5) limit are compared with the experiment.

0_1^+ and 2_2^+ states of ^{152}Gd and ^{154}Dy. These parameters (Eq.2-4) are also related to the α, β and γ parameters. The values of these parameters are given below in Table 1

These c_0, c_2 and c_4 boson-boson interaction

parameters, which are calculated from the experimental data, are used to calculate the energy spectrum of the ^{152}Gd and ^{154}Dy of the IBM-1 in the pure SU(5) limit.

TABLE I: The parameters used in the Hamiltonian for the IBM-1 calculations for Gd and Dy isotopes.

Nucleus	c_0	c_2	c_4	α	β	γ
^{152}Gd	-7.31	420.6	66.8	268.9	-64.5	-25.2
^{152}Dy	-8.4	357.8	77.5	237.6	-48.63	-20.02

Conclusion

The present calculation shows that the energy spectrum of the even-even nuclei can be reproduced well, on including a large number of energy levels. The IBM-1 yields a sequence of the g-, β-, γ- and multi-phonon ($K^\pi = 0_3^+$, 0_4^+, 2_2^+) bands.

References

[1] A. Arima and F. Iachello, Advances in Nuclear Physics, **13**, 139 (Plenum Press, New York) (1984).
[2] O. Scholten, Intercating Boson in Nuclear Physics, edited by F. Iachello (Plenum Press, New York), 17 (1979).
[3] G. Puddu, O. Scholten and T. Otsuka, Nucl. Phys. A , **348**, 109(1980).
[4] R. Bijker, A. E. L. Dieperink, O. Scholten and R. Spanoff, Nucl. Phys. A , **344**, 207(1980).
[5] P. D. Duval and B. R. barrett, Phys. Rev. C, **23**, 492 (1981).
[6] R. F. Casten and P. von Brentano, Physics Letter, **152**, 28 (1985).
[7] P. O. Lipas, P. Haapakoski and T. Honkaranta, Phys. Scr., **13**, 339 (1976).
[8] M. Sakai and A. C. Rester, At. Data and Nucl. Data Tables, **31**, 399 (1984).