The study of different dynamical symmetries in $^{144-154}$Nd isotopes

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Introduction

The interacting boson model in its simplest form, as originally proposed, describes a system of s(l=0) and d(l=2) bosons which may interact with one another via one-or two-body interactions [1]. The change in the structure of the nuclei have been proposed to be related with exceptionally strong neutron-proton interaction. Within the region of medium-heavy and heavy nuclei, a large number of nuclei exhibit properties that are neither closed to anharmonic vibrational spectra nor to deformed rotors. The standard description of these phenomena has been given in terms of nuclear triaxiality going from rigid triaxial shape to soft potential energy surfaces. Within the interacting boson model, when no distinction is made between proton and neutron variables, triaxiality can be described through the introduction of cubic term in the boson operators.

There are several equivalent ways of writing Hamiltonian H [2]. The most general Hamiltonian that can been used to calculate the level energies is

$$H = \epsilon n_d + a_0 P^\dagger.P + a_1 L.L + a_2 Q.Q + a_3 T_3.T_3 + a_4 T_4.T_4 \quad (1)$$

Usually the first four terms, namely the boson energy term, and the a_0, a_1, and a_2 terms are adequate for the phenomenological fit to the low energy spectrum of the nucleus. The computer program code PHINT was used for the construction of the IBM Hamiltonian. The input parameters EPS, ELL, QQ, OCT and HEX are related to the coefficients ϵ, a_0, a_1, a_2, a_3, a_4 respectively, where $EPS = \epsilon$, $PAIR = a_0/2$, $ELL = 2a_1$, $QQ = 2a_2$, $OCT = a_3/5$ and $HEX = a_4/5$.

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Interacting boson model has a very definite group structure, that of the group U(6). Different reductions of U(6) give three dynamical symmetry limits known as harmonic oscillator, deformed rotor and asymmetric deformed rotor which are labeled by U(5), SU(3) and O(6), respectively.

$$U(6) \supset U(5) \supset O(5) \supset O(3)$$
$$U(6) \supset SU(3) \supset O(3)$$
$$U(6) \supset O(6) \supset O(5) \supset O(3)$$

The energy eigenvalue for three chains are

$$E^{(I)}(N, n_d, \nu, n_\Delta, L) = \epsilon n_d + \alpha \frac{1}{2} n_d(n_d - 1) + \beta[n_d(n_d + 3) - \nu(\nu + 3)] + \gamma[L(L + 1) - 6n_d]$$

$$E^{(II)}(N, \lambda, \mu, L) = \left(\frac{3}{4}\kappa - \kappa'\right) L(L + 1) - \kappa[\lambda^2 + \mu^2 + \lambda\mu + 3(\lambda + \mu)]$$

$$E^{(III)}(N, \sigma, \tau, \nu_\Delta, L) = A\frac{1}{4}(N - \sigma)(N + \sigma + 4) + B\frac{1}{6}\tau(\tau + 3) + CL(L + 1).$$

Results and Discussion

Figure 1 shows the variation of ratio of B(E2) transition values represented as $R_1 = B(E2; 4_1 \to 2_1)/B(E2; 2_1 \to 0_1)$, $R_2 = B(E2; 2_2 \to 2_1)/B(E2; 2_1 \to 0_1)$, $R_3 = B(E2; 2_2 \to 0_1)/B(E2; 2_2 \to 2_1)$ and $R_4 = B(E2; 4_1 \to 2_1)/B(E2; 2_2 \to 2_1)$ with the neutron number (N). We compared these obtained results with the experimental values, calculated IBM-2 values and SU(5), SU(3), O(6) symmetries for $^{144-154}$Nd isotopes. Neodymium isotopes in most of the cases show SU(3) symmetry values.

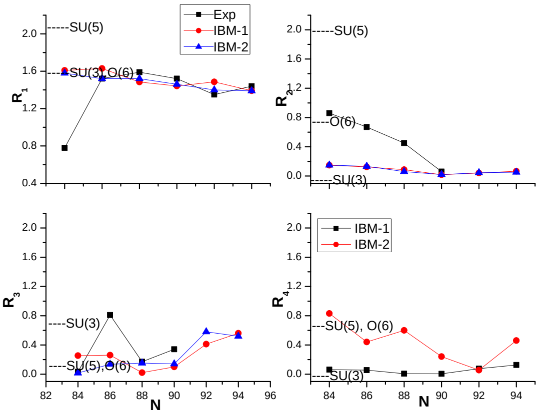

FIG. 1: Comparison of systematic of basic observable in Nd isotopes showing $R_1 = B(E2; 4_1 \rightarrow 2_1)/B(E2; 2_1 \rightarrow 0_1)$, $R_2 = B(E2; 2_2 \rightarrow 2_1)/B(E2; 2_1 \rightarrow 0_1)$, $R_3 = B(E2; 2_2 \rightarrow 0_1)/B(E2; 2_2 \rightarrow 2_1)$ and $R_4 = B(E2; 4_1 \rightarrow 2_1)/B(E2; 2_2 \rightarrow 2_1)$ ratios of $^{144-154}$Nd isotopes with that SU(5), SU(3), O(6) dynamical symmetry limits.

In Figure 2, we show the variation of $B(E2; J \rightarrow J-2)/B(E2; 2_1 \rightarrow 0_1)$ with spin (J) and compared these results with experimental values, calculated IBM-2 values, X(5) symmetry values, rotor and vibrator values. Calculated values of IBM-1 for $^{144-154}$Nd isotopes lies between X(5) symmetry to the rotor or SU(3) symmetry values. In most of the cases the values are very close to the rotor and also show a good agreement with the experimental values. Therefore the $^{144-154}$Nd isotopes show the SU(3) symmetry.

Conclusion

It was seen that some Nd nuclei, especially nuclei around N=90, with yrast energies follow the X(5) prediction closely. But X(5) behavior can be excluded on the basis of the deduced yrast $B(E2; J \rightarrow J-2)$ values in most of the cases. The detailed experimental measurements of the excited states in ^{148}Nd and ^{152}Nd is required. The present study will be important for understanding the collective excitations in transitional nuclei regarding the

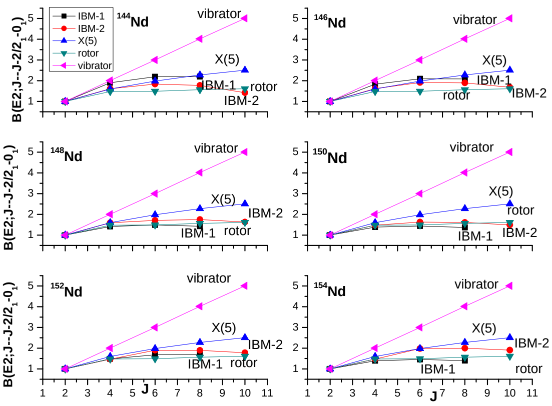

FIG. 2: Comparison of relative γ-band energies in $^{144-154}$Nd with X(5), IBM-2 and an axial rotor.

applicability of the IBM and the X(5) description.

Acknowledgments

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