Search of O(6) symmetry in A=120-200 mass region

Vidya Devi,* Neha Sharma, and H.M. Mittal
Dr B. R. Ambedkar, National Institute of Technology Jalandhar-144011, INDIA

Introduction

The Interacting Boson Model (IBM) is introduced by Arima and Iachello [1] which is alternative approach to describe the collective state of even-even nuclei. The low lying collective states in even-even nuclei can be described by a system of interacting s and d bosons carrying angular momentum 0 and 2 respectively. The IBM provide an algebraic description of various symmetries of the U(6) group, SU(5), SU(3) and O(6) [2, 3]

$$U(6) \supset \begin{cases} U(6) \supset U(5) \supset O(5) \supset O(3) \\ U(6) \supset SU(3) \supset O(3) \\ U(6) \supset O(6) \supset O(5) \supset O(3) \end{cases} \quad (1)$$

All these three limits have been realized the good approximation in nuclei. At the first IBM only describe the SU(5) and SU(3) limits since these describe vibrational and rotational spectra. The O(6) limit on the other hand was viewed as a major new prediction of the model. In present work we search the O(6) symmetry in A=120-200 mass region nuclei and the variation of $B(E2; 2_g \rightarrow 0_g)$ values with N.

Calculation

The Hamiltonian of the O(6) chain leads to the standard energy eigenvalue expression [1]

$$E([N]\sigma\tau\widetilde{v}_{\Delta}LM) = P\frac{1}{4}(N-\sigma)(N+\sigma+4) + Q\frac{1}{6}\tau(\tau+3) + RL(L+1) \quad (2)$$

where P, Q and R are three parameters and P controls the separation between states belonging to the σ families, Q controls the spacing between different τ values, and R relates to the degeneracy splitting within a τ multiplet. For low lying group of levels, with σ =N therefore the first term equal to zero. By putting the value of N, σ, τ and L in eq.(2) we calculated the value of Q and R for which experimental data are taken from Sakai [4] and www.bnl.nndc.gov [5]

$$Q = \frac{3}{2}\left[E(2_g^+) - \frac{6}{14}[E(4_g^+) - E(2_\gamma^+)]\right] \quad (3)$$

and

$$R = \frac{1}{14}\left[E(4_g^+) - E(2_\gamma^+)\right] \quad (4)$$

Result and Discussion

The level energies can serve to prove the O(6) symmetry if levels with $\sigma < N$, are found, and obey the O(6) energy formula. The condition to show O(6) nuclei is that $R_{4/2}$=2.5, another condition is to test the validity of the expression for B(E2) ratios as

$$\frac{B(E2; 4_g \rightarrow 2_g)}{B(E2; 2_g \rightarrow 0_g)} = \frac{10}{7}\frac{(N-1)(N-5)}{N(N+4)} \xrightarrow[N\rightarrow\infty]{} \frac{10}{7} \approx 1.4 \quad (5)$$

and

$$\frac{B(E2; 0_\beta \rightarrow 2_g)}{B(E2; 2_g \rightarrow 0_g)} = 0 \quad (6)$$

The comparison of experimental and theoretical B(E2) ratios in O(6) limit are listed in Table 1. We observed that calculated B(E2) ratio of $^{120-124}$Xe are approximately equal to

*Electronic address: vidyathakur@yahoo.co.in

TABLE I: Comparison of experimental and theoretical B(E2) ratios of O(6) symmetry.

N_B	Xe	Ba	Ce	Nd	Pt	Theo.
			Expt.			
11						1.39
10	1.46		1.35			1.38
9	1.47	1.12	1.39	1.42		1.38
8	1.29	1.03	0.56		1.51	1.35
7		0.90			1.35	1.34
6					1.39	1.31
5		1.5				1.30
4					1.27	1.21

experimental B(E2) ratios and having $R_{4/2}$ =2.5. Therefore these nuclei satisfy the conditions of O(6) symmetry. In case of $^{126-128}$Ba the energy levels is same up to I = 6^+ state, above this state there is rise in theoretical energy values but still there energy ratio $R_{4/2}$ = 2.5 and $B(E2)_{expt} \approx B(E2)_{th.}$, hence it is close to the O(6) symmetry.

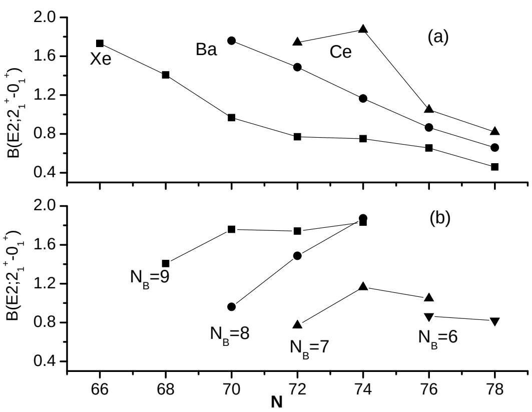

FIG. 1: (a) Variation of $B(E2; 2_1 \rightarrow 0_1)$ in e^2b^2 with neutron number (b) Data link for the same boson number.

In ^{130}Ce the $B(E2)_{expt}$ = 1.35 [6], $B(E2)_{th.}$ =1.38 and in ^{132}Ce the experimental and theoretical energies of O(6) limit are equal [7]. In ^{194}Pt the $B(E2)_{expt}$ = 1.38 [8] and $B(E2)_{th.}$ is also equal to 1.34 therefore these isotope also have O(6) character. Now we test the condition on $B(E2; L+2 \rightarrow L)$. First we study the $B(E2; 2_g \rightarrow 0_g)$ satisfy the first condition of O(6) symmetry. There are many nuclei such as Xe, Ba, and Ce region described in terms of γ - soft rotational nuclei. In Table 1 we see that Xe, Ba, and Ce nuclei shows a close agreement between experimental and theoretical B(E2) ratio. The $^{186-188}$Pt shows the O(6) symmetry. We have observed that B(E2) ratios satisfy the condition and there experimental energy are equal to the theoretical for a given series of isotopes and there $R_{4/2}$ ratios are also ≈ 2.5.

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