The study of $^{126-136}$Ba isotopes in the frame work of interacting boson model

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

Introduction

The interacting boson model (IBM-1), initially introduced by Arima and Iachello [1] has been rather successful in describing the collective properties of several medium and heavy nuclei. 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. In spite of its simplicity it is capable of providing a beautiful theoretical explanation of the observed spectra exhibited by many nuclei. During the past few years, countless calculations within the frame work of the interacting boson model (IBM) has proved to be a valuably interpretive, predictive and in understanding the nuclear structure. Turkan [2] study the E(5) behavior: IBM and Bohr-Mottelson model with Davidson potential calculations of some even-even Xe isotopes. In this work, a projection of IBM-2 parameters onto IBM-1 is used to describe the nuclear structures of $^{122-124}$Xe nuclei. The general Bohr Hamiltonian (GBH) used for the description of low-lying collective states in even-even isotopes of Te, Xe, Ba, Ce, Nd and Sm nuclei along the region 50< N <82 [3]. Turkan [2] gives the calculations for even-even $^{128-138}$Ce nuclei by using the microscopic interacting boson model. In this study they determined the most appropriate Hamiltonian that help to calculate the energy levels and B(E2) values of $^{128-138}$Ce nuclei. In the present work IBM-1 is used to describe the nuclear structure of $^{126-136}$Ba isotopes. The structure of such isotopes was undertake to provide more detail on the neutron rich isotope. Interacting boson model is used to calculate the g-, β-, γ band energy spectra and the B(E2) transition probabilities of $^{126-136}$Ba nuclei.

*Electronic address: `mittahm@nitj.ac.in`

A. Theoretical framework

The IBM-1 Hamiltonian can be written as

$$H = \epsilon'' \hat{n}_d + a_0 P^+ P + a_1 \hat{L}^2 + a_2 Q^2 + a_3 T_3^2 + a_4 T_4^2, \quad (1)$$

where

$$P = \frac{1}{2}(\tilde{d} - s^2)$$

$$T_l = (d^\dagger \tilde{d})^l, l = 0, 1, 2, 3, 4,$$

$$Q = (d^\dagger + s^\dagger \tilde{d}) - \frac{\sqrt{7}}{2}(d^\dagger \tilde{d})^2$$

$$= (d^\dagger s + s^\dagger \tilde{d}) - \frac{\sqrt{7}}{2} T_2,$$

$$\hat{n}_d = \sqrt{5} T_0, \quad \hat{L} = \sqrt{10} T_l$$

The program code PHINT written by Scholten [5] is used within the option of specifying the parameters in the neutron proton formalism where it take care of projecting maximum symmetry states. We have used EPS, PAIR, ELL, QQ parameters and kept OCT, HEX as zero since there contribution is very small. For these calculation the experimental data are taken from [4].

Result and Discussion

In Fig. 1 we see the variation of the $E(2_1^+)$ energy of $^{126-136}$Ba nuclei with neutron number (N). The calculated $E(2_1^+)$ energy shows good agreement with the experimental energy

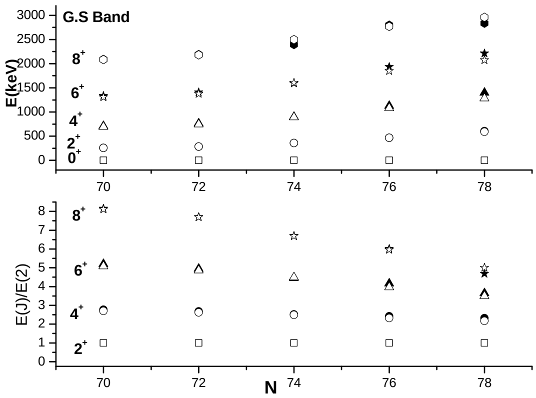

FIG. 1: Results of the calculated energies of g-bands and energy ratios $E(J)/E(2_1^+)$ are shown along with the experimental ones for $^{126-136}$Ba isotopes.

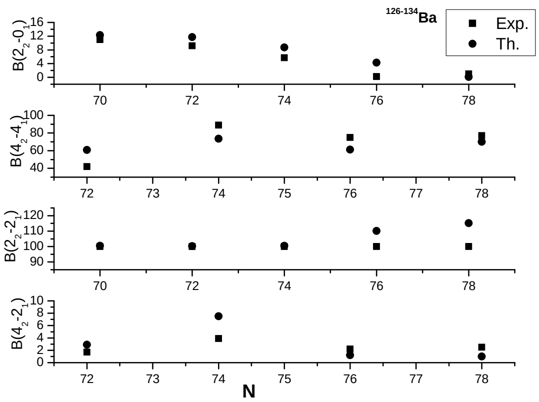

FIG. 2: The calculated $B(E2;4_2^+ \rightarrow 2_1^+)$, $B(E2;2_2^+ \rightarrow 2_1^+)$, $B(E2;4_2^+ \rightarrow 4_1^+)$ and $B(E2;2_2^+ \rightarrow 0_1^+)$ changing as a function of neutron number for $^{126-136}$Ba nuclei.

values. This figure also contains the systematic of basic observable in Ba isotopes showing $R_{4/2}$, $R_{6/2}$, $R_{8/2}$ and $R_{10/2}$ are the function of N = 70 to 78. The behavior of the ratio of the energies of the first 4_1^+ and 2_1^+ states is a good criterion for the shape transition. The energy ratio decreases with increasing the N. The calculated results show that the $R_{4/2} > 2$ for all Ba isotopes and it means that these structure seems to be verifying gamma soft rotor to vibrator nuclei. The energy spectrum of the $^{126-136}$Ba nuclei lie between vibrator and rotational limit. In Fig.2 we show the $B(E2;4_2^+ \longrightarrow 2_1^+), B(E2;2_2^+ \longrightarrow 2_1^+), B(E2;4_2^+ \longrightarrow 4_1^+)$ and $B(E2;2_2^+ \longrightarrow 0_1^+)$ changing with N for $^{126-136}$Ba nuclei. We observed that the calculated $B\,(E2)$ values are in good agreement with the experimental values.

Conclusion

In present work IBM-1 is applied to $^{126-136}$Ba isotopes to find the $g-, \beta-, \gamma-$ band energy spectra, $B(E2)$ values and $B(E2)$ ratios of the nuclei. A good agreement between the calculated and experimental values are found in many cases. The transitions between the three limit symmetries of the model corresponding to different nuclear shape and electromagnetic transitions between them are reasonably described.

Acknowledgments

We are grateful to Dr. J. B. Gupta (Ramjas College, Delhi University, Delhi) for constant encouragement and M.H.R.D for finical support.

References

[1] A. Arima and F. Iachello, Ann. Phys. (N.Y), **99** 253 (1976).
[2] N. Turkan, J. Phys. G. Nucl. Part. Phys. **34**, 2235 (2007).
[3] L. Prochniak. K. Zajac and K. Pomorski, Nucl. Phys. A, **648**, 181 (1999).
[4] http: // www.nndc.bnl.gov/
[5] O. Scholten, (1978) 'Interacting boson in Nuclear Physics' edited by F. Iachello, (Plenum Press, New York) 17 (1979).