The study of transition probabiliies in low-lying levels of light Mg-Zr nuclei

Vidya Devi*
IET Bhaddal, Ropar, Punjab-India

Introduction

The change from spherical to deformed structure is related to an exceptionally strong neutron-proton interaction. The neutron-proton effective interactions have a deformation producing tendency, while the neutron-neutron and proton-proton interactions are of a spherical nature [1, 2]. Within the region of medium-heavy and heavy nuclei exhibit properties that are neither close to the anharmonic quadrupole vibrational spectra nor to the deformed rotor [3]. In the first version of the IBM [4] no distinction is made between proton and neutron variables while describing triaxiality explicitly.
The phenomenological Interacting Boson Model (IBM) initially introduced by Arima and Iachello [5] has been rather successful in describing the properties of several medium and heavy mass nuclei. The basic idea of IBM is to assume that low-lying collective states in even-even nuclei can be described by a system of interacting s-boson and d-boson carrying angular momentum 0 and 2, respectively.

According to Arima et. al [5], IBM Hamiltonian takes on different forms, depending on the regions SU(5), SU(3), O(6) of the traditional IBM triangle. The most general Hamiltonian that has been used to calculate the level energies is [6]

$$H = \mathrm{EPS} n_d + \mathrm{PAIR}(P \cdot P) + \frac{1}{2}\mathrm{ELL}(L \cdot L) + \frac{1}{2}QQ(Q \cdot Q) + 5\mathrm{OCT}(T_3 \cdot T_3) + 5\mathrm{HEX}(T_4 \cdot T_4)$$

The computer program code PHINT [7] was used for the construction of the IBM-1 Hamiltonian and for its solution on the SU(5) basis.

*Electronic address: `vidya.thakur@ietbhaddal.edu.in`

A. The E2 and B(E2) transitions

For the E2 transitions one uses the transition operator T(E2) which is related to the quadrupole operator Q of the Hamiltonian

$$T(E2) = e_b Q = \alpha[d^\dagger s + s^\dagger \tilde{d}]^{(2)} + \beta[d^\dagger \tilde{d}]^{(2)} \quad (1)$$

Also the charge parameters $\alpha(= e_b)$ and $\beta(= e_b\chi)$ in Eq.(1) are called E2SD and E2DD, respectively. In the consistent Q formalism [8], one uses the same form of the quadrupole operator for the Hamiltonian as well as the $T(E2)$ operator (i.e. the same value of χ). For this, one employs the level energy data as well as the $B(E2)$ values to determine the parameters of H and $T(E2)$. The $B(E2)$ branching ratio for two transitions from a particular level in a given band to the two states of other band, i.e. $(I_i \rightarrow I_f/\dot{I}_f)$, depends on the Alaga value In the SU(3) [5] these rules are slightly modified because the $(\gamma \rightarrow g)$ and $(\beta \rightarrow g)$ transitions are prohibited, but in the slightly broken symmetry the $(\gamma \rightarrow g)$ transition should be faster than $(\beta \rightarrow g)$ transition.

Result and Discussion

Figure shows B(E2) transition probabilities of same levels for even-even Mg-Zr isotopes. We present the $(BE2; J \rightarrow J-2)$ reduced transition strength which is normalized to the respective $(BE2; 2_1 \rightarrow 0_1)$ values and compared them with anharmonic vibrator, an axially deformed rotor and X(5) predictions. The calculated IBM-1 and experimental values are near to the rotor values. In case of ^{76}Kr the values also lie closest to the rotor values. For ^{78}Kr the calculated and experimental values lie in between X(5) symmetry and rotor values.

Some important reduced E2 transition proba-

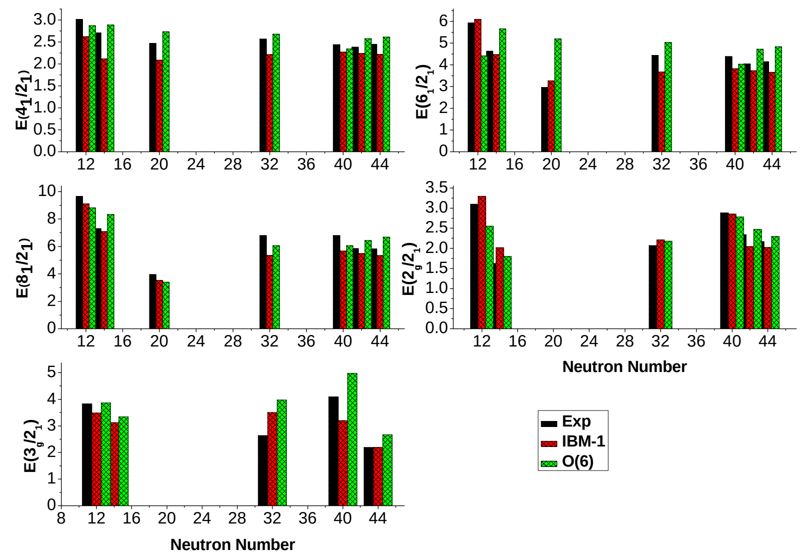

FIG. 1: The variation of $E(2_\gamma/2_1)$, $E(3_\gamma/2_1)$, $E(4_\gamma/2_1)$, $E(6_\gamma/2_1)$, and $E(8_\gamma/2_1)$ with neutron number (N).

bilities for $^{76-78}$Se are given in Table 1. These calculated values are in good agreement with the experimental values. In most of the cases, the deviations from the experimental values are smaller than 10%.

TABLE I: Theoretical and experimental gsb levels in MeV for Mg-Zr nuclei. The fitting parameters a, b in Eq. are given in MeV. The RMS factor σ is also given in MeV.

	B(E2)e^2fm^4	Exp.	IBM-2	IBM-1
^{76}**Se**	$B(E2;2_1^+\to0_1^+)$	0.0840	0.081	0.0836
	$B(E2;2_2^+\to0_1^+)$	0.0022	0.0026	0.0019
	$B(E2;2_3^+\to0_1^+)$	0.0007	0.0001	0.0004
	$B(E2;2_3^+\to2_2^+)$	0.0140	0.0119	0.0109
	$B(E2;4_1^+\to2_1^+)$	0.1361	0.1220	0.1491
	$B(E2;3_1^+\to2_1^+)$	0.0062	0.0035	0.0018
	$B(E2;4_2^+\to4_1^+)$	0.0056	0.0066	0.0057
	$B(E2;6_1^+\to4_1^+)$	0.160	0.137	0.189
	$B(E2;4_2^+\to2_2^+)$	0.067	0.076	0.089

Conclusion

The interacting boson model is used to calculate the energy spectra and compared these predictions with experimental energy. A good agreement between the calculations and experiments is found in many cases. The transitions between the three limit symmetries of the model corresponding to the different nuclear shape and electromagnetic transitions is observed.

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