B(E2) value of even-even $^{124-130}$Barium transitional nuclei with cubic terms from Casimir invariant operators and IBM-1

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Abstract

Several characteristics of nuclear structure for even-even 124-130Barium nuclei have been explored with Interacting Boson Model. This work studies the systematic reduced transition probabilities B(E2) ↓ of Ba isotopes with even neutrons from N=68 to 74. The values of parameters have been determined with the formation of cubic terms by Casimir invariant operators and addition of these terms by breaking O(6) symmetry of IBM Hamiltonian. We have studied systematically the transition rate R=B(E2: L+→(L-2)+)/ B(E2: 2+→0+) of some of the low-lying quadrupole collective states in comparison with available experimental data. The results of this calculation are in good agreement with available experimental data. The even-even $^{124-130}$Barium isotopes show O(6) symmetry.

INTRODUCTION

There are a lot of dignified paradigms to examine and comprehend the nucleus structure, which contains a harmonic vibrator, axial rotor, and gamma soft deformed nuclei. Iachello and Arima developed a new approach to nuclear collective motion in 1975 i.e., interacting boson model [1-6]. IBM-1 represents an even-even nucleus as a system of N bosons capable to catchup two levels. One with L=0, called s bosons and other with L=2 called d bosons. The s-bosons have energy ϵs, the d-bosons ϵd. The energy of a boson is defined by ϵ = ϵd-ϵs. L is angular momentum and N is total number of bosons, equal to s bosons plus the number of d bosons. An energy spectrum is not enough to recognize the structure of nucleus. The understanding of wave functions of states is pivotal. The best familiar method of investigating the wave function by probing the B(E2) means reduced transition probability.

The main objective of this work is to calculate B(E2) values of 124-130Barium transitional nuclei with cubic terms from Casimir invariant operators and IBM-1.

METHOD OF CALCULATIONS

The Hamiltonian for IBM-1 can be exposed as a linear combination of the U(6) and its subgroup linear and quadratic Casimir operators:

$$
\begin{aligned}
&\kappa_1\hat{C}_1[U(5)] + \kappa_1'\hat{C}_2[U(5)] + \kappa_2\hat{C}_2[SU(3)] \\
&+ \kappa_3\hat{C}_2[SO(6)] + \kappa_4\hat{C}_2[SO(5)] + \kappa_5\hat{C}_2[SO(3)] \\
&+ \kappa_6\hat{C}_1[U(6)] + \kappa_6'\hat{C}_2[U(6)] \\
&+ \kappa_7\hat{C}_1[U(6)]\,\hat{C}_1[U(5)] + f_1[\hat{C}_1[U(5)]]^3 \\
&+ f_2\hat{C}_2[SO(5)]\hat{C}_1[U(5)] + f_2'\hat{C}_2[SO(3)]\,\hat{C}_1[U(5)] \\
&+ f_3\,\hat{C}_2[U(6)]\,\hat{C}_1[U(6)] + f_4\,\hat{C}_1[U(6)]\,\hat{C}_2[U(5)] \\
&+ f_5\hat{C}_2[SO(5)]\hat{C}_1[U(6)] + f_6\hat{C}_2[SO(3)]\,\hat{C}_1[U(6)] \\
&+ f_7[\hat{C}_1[U(6)]]^3
\end{aligned}
$$

RESULTS AND DISCUSSION

124-130Ba isotopes reveal a magnificent opportunity for studying deportment of the total low lying E2 strengths in the transition region from deformed to spherical nuclei. Transition level, boson number (N) and downward reduced transition probabilities B(E2) for the ground state band from 8^+ to 6^+, 6^+ to 4^+, 4^+ to 2^+ and 2^+ to 0^+ of 124-130Ba isotopes are shown in Table 1. Using known experimental B(E2) ↓ from $2_1^+ \to 0_1^+$transition, B(E2) ↓ value of $4_1^+ \to 2_1^+$,$6_1^+ \to 4_1^+$and $8_1^+ \to 6_1^+$transitions of Ba isotopes are computed using IBM-1.

Isotopes	N	Transition Level	B(E2) values in e^2b^2	
			Experimental	IBM-1
^{124}Ba	10	$2^+\to0^+$	0.418	0.418
		$4^+\to2^+$	-	0.752
		$6^+\to4^+$	-	1.003
		$8^+\to6^+$	-	1.170
^{126}Ba	9	$2^+\to0^+$	0.352	0.351
		$4^+\to2^+$	0.472	0.625
		$6^+\to4^+$	0.550	0.821
		$8^+\to6^+$	0.630	0.938
^{128}Ba	8	$2^+\to0^+$	0.275	0.272
		$4^+\to2^+$	0.352	0.480
		$6^+\to4^+$	0.380	0.612
		$8^+\to6^+$	0.309	0.680
^{130}Ba	7	$2^+\to0^+$	0.226	0.226
		$4^+\to2^+$	0.394	0.388
		$6^+\to4^+$	0.387	0.485
		$8^+\to6^+$	0.368	0.517

Conclusion

Reduced transition probabilities B(E2) ↓ is the most important observable to examine change in nuclear shapes. So, we have calculated the B(E2) values of 124-130Ba isotopes with cubic terms from Casimir invariant operators and IBM-1. The calculated values are consistent with experimental results. The values of energy ratio R(4/2) of 124-130Ba isotopes show O(6) symmetry.