The study of ^{108}Cd and ^{110}Cd isotopes in the frame work of interacting boson model

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Introduction

Atomic nuclei are known to exhibit changes of their energy levels and electromagnetic transition rates among them when the numbers of protons (or neutrons) are modified, resulting in the shape transition from one kind of collective behavior to another [1]-[3]. The even-mass cadmium isotopes have been extensively investigated both theoretically and experimentally in recent years with special emphasis on interpreting experimental data via collective models [4]. The collective character in medium-mass nuclei has been successfully described by Arima and Iachello using the interacting boson model-1 (IBM-1) [5]. There is no distinction of IBM-1 for proton and neutron degree of freedom. Recently, many researches on the structure of electromagnetic transition properties and energy levels of doubly even Cd isotopes have been investigated [6]. Cadmium isotopes are good examples of quadrupole vibration nuclei. However, during the last few years, new experimental data and calculations have led to a modified picture on these nuclei.

Energy level The IBM-1 provides theoretical level energies while including anharmonicities from residual interactions. The vibrational model uses a geometric approach, the IBM employs a severely truncated model space, and as such, calculations are possible for nuclei with N nucleons, providing a quantitative mechanism to compare experimental results and calculated values [7]. In the first approximation of IBM-1, only pairs with angular momentum L=0 (called s-bosons) and L= 2 (called d-bosons) are considered [8]. The energy levels are calculated using the computer program PHINT [9].

In the present work an attempt is made to study the behavior of the back bending phenomena in the ground state here are several equivalent ways of writing Hamiltonian H [1]. The most general Hamiltonian that has been used to calculate the level energies is

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

where

$$n_d = (d^\dagger.\tilde{d}), \quad P = \frac{1}{2}(\tilde{d}.\tilde{d}) - \frac{1}{2}(\tilde{s}\cdot\tilde{s})$$
$$L = \sqrt{10}\left[d^\dagger \times \tilde{d}\right]^{(1)}$$
$$Q = \left[d^\dagger \times \tilde{s} + s^\dagger \times \tilde{d}\right]^{(2)} - \frac{1}{2}\sqrt{7}\left[d^\dagger \times \tilde{d}\right]^{(2)}$$
$$T_3 = \left[d^\dagger \times \tilde{d}\right]^{(3)}, \quad T_4 = \left[d^\dagger \times \tilde{d}\right]^{(4)}.$$

In the Hamiltonian, d-boson energy (EPS=ϵ_d), n_d (number of d-bosons) and $P \cdot P$ terms produce the characteristics of U(5) and O(6) structures. So the Hamiltonian is a mixture of the SU(5) and O(6) chains, but not diagonal in any of the IBM chains.

Result and Discussion

The $R_{4/2} = E(4^+)/E(2^+)$ values for ^{108}Cd and ^{110}Cd isotopes is 2.4 that are near to the γ-soft nuclei. The IBM-1 calculation for both nuclei shows close agreement with the experimental values.

In order to achieve the low-lying energy levels of Cd isotopes in the mass region A=104-122 by IBM-1, it is important to specify the

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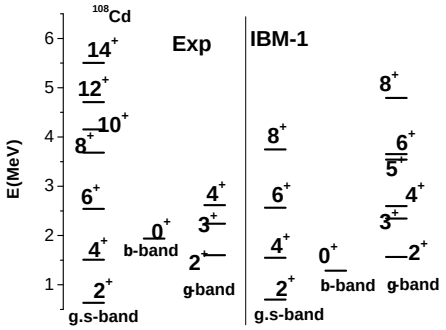

FIG. 1: Result of experimental and IBM-1 of ground, quasi-beta, and quasi gamma band for ^{108}Cd isotopes.

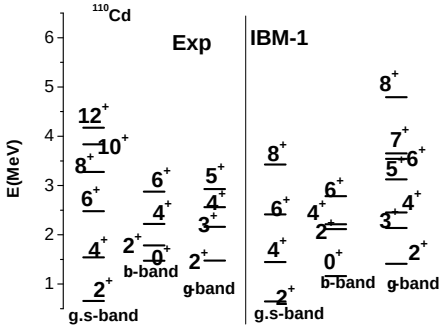

FIG. 2: Result of experimental and IBM-1 of ground, quasi-beta, and quasi gamma band for ^{110}Cd isotopes.

shape symmetry of a nucleus, which can be predicted from the energy ratio. The energy spectra are obtained by diagonalizing the IBM-1 Hamiltonian. The parameters used are listed in table 1. The figure 1 and figure 2 shows a comparison between calculated and experimental values.

Conclusion

The present calculation shows that the energy spectrum of the even-even nuclei can be reproduced well, on including a large number of energy levels. We have concluded that the general characteristics of the Cd isotopes are well accounted in this review and idea of shape coexistence in this region is supported. It is established that the framework of interacting boson approximations showed that Cd isotopes under study are considered as vibration nuclei and close to the SU(5)-SO(6) transitional region of IBM-1.

TABLE I: The parameters used in the Hamiltonian for the IBM-1 calculations for ^{108}Cd and ^{110}Cd isotopes.

EPS	PAIR	ELL	QQ	CHI
0.900	0.0010	0.0220	-0.0350	2.900
0.800	0.0010	0.0250	-0.0300	2.900

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