Nuclear structur of Pd nuclei in the framework of IBM-1 and odd even staggering

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Introduction

The phenomenological Interacting Boson Model (IBM) initially introduced by Arima and Iachello [1] 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. The three possible dynamic symmetries are generally labeled by the first subalgebra are U(5); harmonic vibrator [3], SU(3); symmetrically deformed rotor [4] and O(6); triaxially soft rotor [5].
Nuclei may display behavior near these idealized limits and it is a recent approach to apply the ideas of phase transition of the nuclear shape [2]. Definition of the critical points of the shape change is stated as new benchmarks and the transition from a spherical harmonic vibrator to an axially deformed rotor has been described analytically [6] by introducing a dynamical symmetry, deformed as X(5).
This dynamical symmetry arises when the potential in the Bohr Hamiltonian [4] is decoupled into two components-an infinite square well potential for the quadrupole deformation parameter β and a harmonic potential well for the triaxiality deformation parameter γ [7]. The signature of a phase transition between collective vibrator and axially deformed rotor has received considerable attention, in the frame of critical point properties in transitional nuclei [8].

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1. The interacting boson model

There are several equivalent ways of writing Hamiltonian H. The most general Hamiltonian that has been used to calculate the level energies is

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

where

$$n_d = (d^\dagger.\tilde{d}), \quad P = \frac{1}{2}(\tilde{d}.\tilde{d}) - \frac{1}{2}(\tilde{s}.\tilde{s})$$

$$L = \sqrt{10}\left[d^\dagger \times \tilde{d}\right]^{(1)}$$

$$Q = \left[d^\dagger \times \tilde{s} + s^\dagger \times \tilde{d}\right]^{(2)} - \frac{1}{2}\sqrt{7}\left[d^\dagger \times \tilde{d}\right]^{(2)}$$

$$T_3 = \left[d^\dagger \times \tilde{d}\right]^{(3)}, \quad T_4 = \left[d^\dagger \times \tilde{d}\right]^{(4)}$$

Usually the first four terms in eq.(1), namely the boson energy terms, and the a_0, a_1, and a_2 terms are adequate for the phenomenological fit to the low energy spectrum of the nucleus. The computer program code PHINT was used for the construction of the IBM Hamiltonian. McCutchan et al. [9] studied the staggering in band energies and the transition between different structural symmetries in nuclei by using the expression

$$S(J) = \big((\{E(J)_\gamma - E(J-1)_\gamma) - (E(J-1)_\gamma - E(J-2)_\gamma)\big)/E(2_1^+) \quad (2)$$

which measures the displacement of the $(J-1)^+_\gamma$ level relative to the average of its neighbors, J^+_γ and $(J-2)^+_\gamma$, normalized to the energy of the first excited state of the ground band, 2_1^+. The idealized geometrical models discussed thus far provide a reasonable qualitative classification of the staggering patterns in the nuclei outline above.

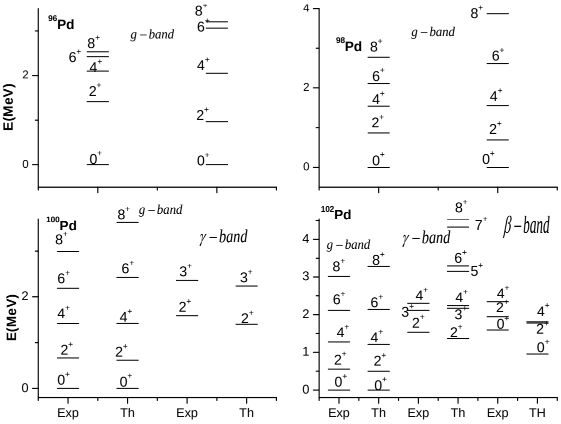

FIG. 1: Result of calculated energies of ground, quasi-beta and quasi-gamma band for $^{96-102}$Pd isotopes.

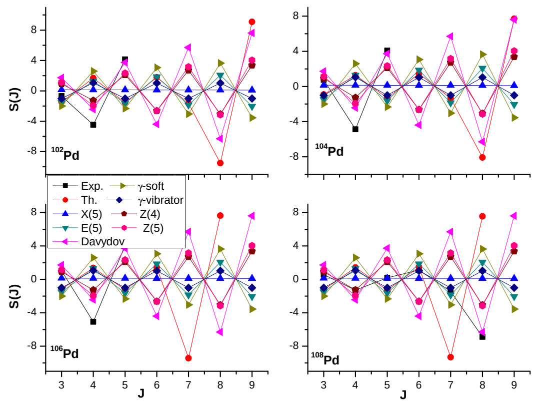

FIG. 2: Staggering S(J) for the IBM-1,X(5), E(5), Davydov, γ-soft, γ-vibrator, Z(4) and Z(5) for $^{102-108}$Pd.

Result and Discussion

Fig.1 show the experimental spectra of the ground state, quasi band and quasi gamma band for the different isotopes of Pd nuclei and also compared with the predicted IBM-1 result. The energy spacing in $^{96-102}$Pd is near to the spherical anharmonic vibrator.

Fig.2 shows the variation of staggering constant S(J) with angular momentum (J) for $^{102-110}$Pd isotopes. These staggering values compared with the triaxial rotor, γ-soft and axial rotor limits to study the behavior of the nuclei. $^{102-110}$Pd isotopes show opposite behavior from the axial rotor limit and the staggering also increases with increase in the angular momentum.

Conclusion

The results of this work show that the IBM-1 provides a good description of even-even Pd isotopes of the nuclei. The results of our phenomenological analysis indicate that the interacting boson model can reproduce a considerable quantity of experimental data. The experimental energy staggering in γ bands of several isotopic chains is investigated as a signature for the γ dependence of the geometric potential.

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