The study of different dynamical symmetry in the Pd isotopes

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Introduction

There have been many attempts to explore the factors responsible for the onset of large deformation in nuclei of the mass region $A \approx 100$. The interacting boson model (IBM) is one of those attempts that has been successful in describing the low lying nuclear collective motion in medium and heavy mass nuclei [1–3]. The purpose of this paper is to set up some even-even nuclei around the mass region $A \approx 100$. The neutron rich even-even Pd isotopes around the mass region $A \approx 100$ are very important for understanding the gradual change from spherical to a deformed state via transitional phase [4]. These nuclei lie between strongly deformed ^{100}Zr and doubly magic ^{132}Sn, near which structural changes are rather rapid with changes in the proton and neutron numbers.

Theoretical frame work

There are several equivalent ways of writing Hamiltonian [3]. The most general Hamiltonian that has been used to calculate the level energies are

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

where

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

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

The energy eigenvalues for three chains are as

$$\begin{aligned} E^{(I)}(N, n_d, \nu, n_\Delta, L) &= \epsilon n_d + \alpha\frac{1}{2}n_d(n_d-1) + \\ &\beta[n_d(n_d+3) - \nu(\nu+3)] \\ &+ \gamma[L(L+1) - 6n_d] \\ E^{(II)}(N, \lambda, \mu, L) &= \left(\frac{3}{4}\kappa - \kappa'\right) L(L+1) - \\ &\kappa[\lambda^2 + \mu^2 + \lambda\mu + 3(\lambda+\mu)] \\ E^{(III)}(N, \sigma, \tau, \nu_\Delta, L) &= A\frac{1}{4}(N-\sigma)(N+\sigma+4) + \\ &B\frac{1}{6}\tau(\tau+3) + CL(L+1) \end{aligned}$$

Figures and Tables

Fig.1 shows the energies of the yrast sequences normalized to the energy of their respectively 2_1^+ levels in $^{102-108}$Pd isotopes and compared with the expected behavior for an anharmonic vibrator, an axially deformed rotor, and the X(5) prediction. In Fig.2 some BE(2) transition ratios of $^{102-108}$Pd isotopes are given and the calculated ratios are compared with that of SU(5), O(6) and SU(3) ratio limits.

In Table 1 we compared some BE(2) transition values with experiment values for $^{102-108}$Pd isotopes. In most cases the deviations from the experimental values are smaller

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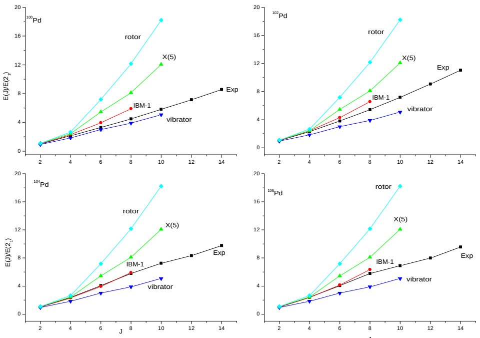

FIG. 1: The energy of the yrast sequences in $^{102-106}$Pd isotopes.

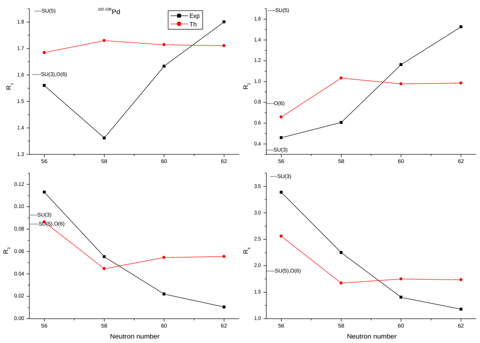

FIG. 2: Comparison of systematic of basic observable in Pd isotopes showing $R_1 = B(E2; 4_1 \to 2_1)/B(E2; 2_1 \to 0_1)$, $R_2 = B(E2; 2_2 \to 2_1)/B(E2; 2_1 \to 0_1)$, $R_3 = B(E2; 2_2 \to 0_1)/B(E2; 2_2 \to 2_1)$ and $R_4 = B(E2; 4_1 \to 2_1)/B(E2; 2_2 \to 2_1)$ ratios of $^{102-108}$Pd isotopes with that SU(5), SU(3) and O(6) dynamical symmetry.

than 10%. The fit of $B(E2; 4_1^+ \to 2_1^+)$ is satisfactory. The transitions from 2_2^+ to the ground state are weak in general, with B(E2)'s 6-10 times smaller than yrast ones. This feature is well described by the model. These values show good comparison with each other.

TABLE I: The experimental and calculated values of BE(2) transitions for $^{102-106}$Pd isotopes.

	^{102}Pd		^{104}Pd		^{106}Pd	
BE(2)	Exp.	IBM-1	Exp.	IBM-1	Exp.	IBM-1
$2_1^+ \to 0_1^+$	923	944	1045	954	1332	1417
$2_2^+ \to 2_1^+$	425	621	633	986	1548	1387
$2_2^+ \to 0_1^+$	48	53	35	44	34	75
$4_1^+ \to 2_1^+$	1440	1225	1423	1657	2175	2429
$2_3^+ \to 2_1^+$		3	<32	23		10^{-3}

Conclusion

The shape transition has been investigated in detail via the IBM framework on even-even Pd isotopes ($^{102-108}$Pd) and the properties predicted by this study is consistent with the spectroscopic data for these nuclei. $^{102-108}$Pd are the typical examples of isotopes that exhibit a smooth phase transition from vibrational nuclei to soft triaxial rotors. Calculated, experimental energies, and BE(2) transition are mostly in agreement with each other. The present study will be important for understanding the collective excitations in transitional nuclei regarding the applicability of the IBM and the X(5) description.

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