Band moment of inertia in Signature partner and Identical SD bands in A = 190 mass region

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I. Introduction

Since the observation of the first high-spin superdeformed (SD) band in ^{152}Dy [1], they have been discovered and intensively studied in several mass regions A ~ 190, 150, 130 and 80. However, it is still difficult to observe the links between the SD bands and normal deformed (ND) states with known spins. Therefore, the exact excitations energies, spins, and parities of SD bands remain uncertain. The discrete γ-rays connecting the states of the yrast SD band ^{194}Hg(1) to ND states with known spins were observed [2] and the spins and excitation energies of all members of ^{194}Hg(1) band were established experimentally. Recently, a link between SD and ND bands has also been observed in ^{190}Hg [3]. Therefore, the measured spins of these SD bands provide a significant test of the validity of the approaches to fix the spins of the SD bands. It is noted that all the available approaches profit from the comparison of the calculated transition energies or dynamic moment of inertia with the experimental results and usually are referred to as the best fit method (BFM). This also implies that the kinematic moment of inertia is also not a well establsihed quantity.

II. Systematics of the kinematic moment of inertia

Bohr and Mottelson [4] pointed out that the rotational energy of K=0 bands in even-even nuclei can be expanded in power series of I(I+1):

$$E(I)=A(I(I+1))+B(I(I+1))^2+C(I(I+1))^3+D(I(I+1)^4 \ldots(1)$$

The energy may also be rewritten as [5] ,

$$E(I)=\frac{1}{J_0}((I(I+1))-\frac{1}{2}\sigma(I(I+1))^2+\sigma^2(I(I+1))^3-3\sigma^3(I(I+1))^4 \quad \ldots(2)$$

where σ is the softness parameter and J_0 is band moment of inertia. Comparison of equations (1) and (2) suggests that, $A=J_0=1/2A$. In fact J_0 thus extracted may be considered as another equivalent parameter characterizing a rotational band, and depends on the intrinsic structure of the rotational band. By using the measured spins or suggested spins from the BFM, S.X. Liu and J.Y. Zeng [6] had studied the systematics of band moment of inertia of SD bands.

(a) Signature partner SD bands

It has been observed that majority of SD bands in A=190 mass region observed in odd-A nuclei and odd-odd nuclei and excited SD bands in even-even nuclei are signature partner SD bands Table I. By fitting the γ ray transition energies and spin in 4-parameter formula (1), we have calculated the parameters A, B, C and D and ultimately the band moment of inertia [see Table I]. It is interesting to note that the band moment of inertia of each signature partner SD bands is almost identical:

$J_0(^{194}Hg(2)) = J_0(^{194}Hg(3)) \sim 91.3\hbar^2MeV^{-1,}$
$J_0(^{195}Hg(1)) = J_0(^{195}Hg(2)) \sim 91.6\hbar^2MeV^{-1}$,
$J_0(^{196}Pb(2)) = J_0(^{196}Pb(3)) \sim 89.6\hbar^2MeV^{-1}$,
$J_0(^{195}Pb(3)) = J_0(^{195}Pb(4)) \sim 90.7\hbar^2MeV^{-1}$,
$J_0(^{193}Tl(1)) = J_0(^{193}Tl(2)) \sim 93.8\hbar^2MeV^{-1}$,
$J_0(^{194}Tl(1)) = J_0(^{194}Tl(2)) \sim 95.3\hbar^2MeV^{-1}$.

Therefore, if there is a significant difference in J_0 values of two SD bands, it is very unlikely that they form a pair of signature partner bands.

(b) Identical SD bands

The yrast SD band ^{192}Hg(1) is considered identical to the excited SD band ^{194}Hg(3), because the observed sequence of E2 transition energies are almost identical in the spin range I ~ 20 - 40 [7]. Which implies their dynamical moment of inertia $J^{(2)}$ are almost identical in this spin range (as can be seen in the Fig. 1). However, the band moment of inertia (which depends intimately on the intrinsic structure of rotational bands) of SD bands ^{194}Hg(3) and ^{192}Hg(1) are quite different, J_0(^{194}Hg(3)) = 91.4ħ^{2}MeV^{-1} >> J_0(^{192}Hg(1)) = 85.1ħ^{2}MeV^{-1} as shown in Table II.

Table I. The systematics of band moment of inertia in signature partner SD bands in A=190 mass region. The experimental data of transition energies and spins are taken from [8,9].

SD band	E_γ(I+2→I)	I	J_0
^{194}Hg(2)	201	8	91.3
^{194}Hg(3)	262	11	91.4
^{195}Pb(3)	236	9.5	90.5
^{195}Pb(4)	214	10.5	90.7
^{195}Hg(1)	334	14.5	91.8
^{195}Hg(2)	274	12.5	91.6
^{193}Tl(1)	207	8.5	93.8
^{193}Tl(2)	227	9.5	93.8
^{194}Tl(1)	268	12	95.3
^{194}Tl(2)	209	9	95.3
^{196}Pb(2)	204	8	89.6
^{196}Pb(3)	227	9	89.6

For two SD bands to be truly identical, it would seem necessary that both the bands have the same band moment of inertia. We, however, find that the two IB have very different values implying that the structure of the two bands is not very similar after all. What then causes the transition energies to be so much similar? This question remains unanswered by the theories.

Table II. The systematics of band moment of inertia in identical SD bands in A=190 mass region. The experimaental data of transition energies and spins are taken from ref. [8,9].

SD band	E_γ(I+2→I)	I	J_0
^{194}Hg(3)	262	11	91.4
^{192}Hg(1)	214	8	85.1

III. Summary

The variations of the band moment of inertia and its systematics are investigated. The systematics suggest that the band moment of inertia turn out to be nearly same for two signature partner bands

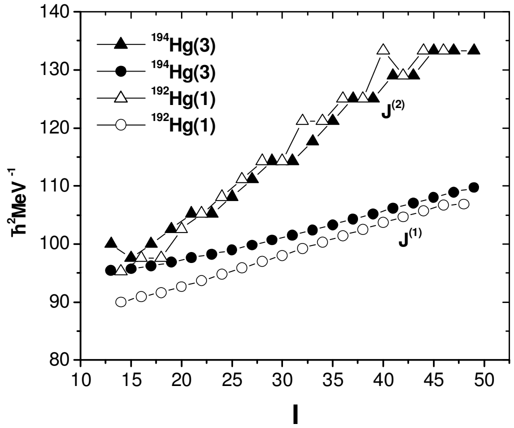

Fig. 1. Plot of the experimental $J^{(1)}$ and $J^{(2)}$ of ^{192}Hg(1) and ^{194}Hg(3).

but the same cannot be said to be true for identical SD bands. This raises an important question about the similarity of the structure of the two IB. We are also investigating the band moment of inertia of other identical SD bands. These and other results will be presented.

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