Measure of Identicity in high-K 3qp rotational bands

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Introduction

Identical bands found in low spin (ND) bands [1], have stimulated great exuberance in Nuclear physics. In the present article, specific examples from the experimental data on identical 3qp high-K rotational bands based on same bandhead spin are discussed and analyzed for the first time. Low-lying positive parity proton pair-broken bands with bandhead spin-parity $K^P = \frac{19}{2}^+[\pi\frac{7}{2}^+[404] \otimes \pi\frac{5}{2}^+[402] \otimes \nu\frac{7}{2}^+[633]]$ are observed in three $^{171,173,175}Hf$ isotopes and these bands in ^{173}Hf and ^{175}Hf nuclei exhibits identical nature. However, the rotational band observed in ^{171}Hf nucleus exhibits identical nature with the 3qp rotational band based on $[\nu\frac{5}{2}^-[512] \otimes \nu\frac{7}{2}^-[514] \otimes \nu\frac{7}{2}^+[633]]$ configuration found in ^{177}W nucleus. Also, negative parity proton-pair broken band with bandhead spin-parity $K^P = \frac{25}{2}^-$ $[\pi\frac{7}{2}^+[404] \otimes \pi\frac{9}{2}^-[514] \otimes \nu\frac{9}{2}^+[624]]$ and positive parity neutron pair-broken band with bandhead spin-parity $K^P = \frac{25}{2}^+$ $[\pi\frac{9}{2}^-[514] \otimes \nu\frac{9}{2}^+[624] \otimes \nu\frac{7}{2}^-[514]]$ are observed in ^{177}Hf and ^{181}Re nuclei respectively. These 3qp rotational bands are found to have identical character too. 3qp rotational band observed in ^{159}Er nucleus with bandhead spin-parity $K^P = \frac{21}{2}^-$ based on $[\pi\frac{7}{2}^-[523] \otimes \pi\frac{7}{2}^+[404] \otimes \nu\frac{3}{2}^+[651]]$ configuration shows identicity with the rotational band of ^{181}Os nucleus with same bandhead spin-parity involving $[\nu\frac{1}{2}^-[521] \otimes \nu\frac{9}{2}^+[624] \otimes \nu\frac{7}{2}^+[633]]$ configuration [2].

Mostly equality of γ-ray energies, kinematic moment of inertia $\Im^{(1)}$ and dynamic moment of inertia $\Im^{(2)}$ of two bands have been chosen as criteria for selection of IBs [3].We did an analysis for IBs in high-K rotational bands based on both moments of inertia. From TABLE I, FIG. (1) and FIG. (2) we can notice the similarity in the γ-ray energies, $\Im^{(1)}$ and $\Im^{(2)}$ of the nuclei pair exhibiting the identical bands. Fractional change in $\Im^{(1)}$ is [3],

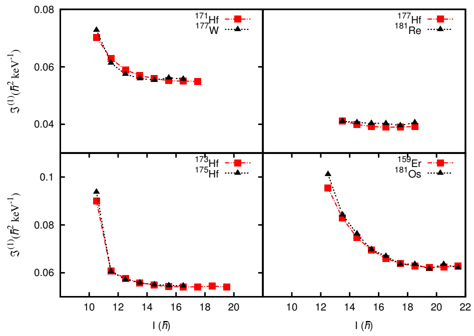

FIG. 1: Kinematic moment of inertia $\Im^{(1)}$ vs. $I(\hbar)$

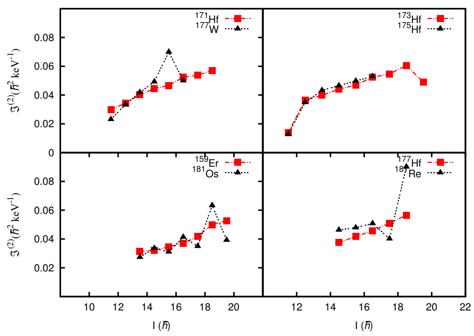

FIG. 2: Dynamic moment of inertia $\Im^{(2)}$ vs. $I(\hbar)$

$$F.C.(A_1) = \frac{\Im^{(1)}_{A_1} - \Im^{(1)}_{A_2}}{\Im^{(1)}_{A_1}}$$

with A_1 and A_2 (A_2<A_1) are the mass num-

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I^π	^{173}Hf E_γ	I^π	^{175}Hf E_γ
$21/2^+$	116.8	$21/2^+$	112.2
$23/2^+$	189.2	$23/2^+$	189.9
$25/2^+$	216.6	$25/2^+$	218.6
$27/2^+$	241.7	$27/2^+$	241.7
$29/2^+$	264.4	$29/2^+$	263.2
$31/2^+$	285.7	$31/2^+$	283.3
$33/2^+$	304.8	$33/2^+$	302.0

I^π	^{171}Hf E_γ	I^π	^{177}W E_γ
$21/2^+$	148.9	$21/2^+$	144.3
$23/2^+$	183.2	$23/2^+$	187.5
$25/2^+$	212.0	$25/2^+$	217.5
$27/2^+$	236.9	$27/2^+$	241.4
$29/2^+$	259.4	$29/2^+$	261.7
$31/2^+$	280.8	$31/2^+$	(276.0)
$33/2^+$	299.9	$33/2^+$	296.0

I^π	^{177}Hf E_γ	I^π	^{181}Re E_γ
$27/2^-$	254.8	$27/2^+$	255.4
$29/2^-$	281.4	$29/2^+$	277.0
$31/2^-$	305.4	$31/2^+$	297.9
$33/2^-$	327.3	$33/2^+$	317.6
$35/2^-$	346.9	$35/2^+$	342.5
$37/2^-$	364.6	$37/2^+$	353.6

I^π	^{159}Er E_γ	I^π	^{181}Os E_γ
$25/2^-$	131.0	$25/2^-$	123.6
$27/2^-$	166.0	$27/2^-$	160.2
$29/2^-$	194.0	$29/2^-$	190.0
$31/2^-$	223.0	$31/2^-$	222.3
$33/2^-$	250.0	$33/2^-$	246.4
$35/2^-$	274.0	$35/2^-$	275.5
$37/2^-$	294.0	$37/2^-$	290.8
$39/2^-$	313.0	$39/2^-$	316.3
$41/2^-$	328.0	$41/2^-$	322.4
$43/2^-$	342.0	$43/2^-$	346.2

Nuclei pair	N	$\Delta E_\gamma/E_\gamma(\%)$	R_γ	$F.C.$
$^{173}Hf,^{175}Hf$	7	1.088	0.562	0.560
$^{171}Hf,^{177}W$	7	1.973	0.334	0.354
$^{177}Hf,^{181}Re$	6	1.965	0.518	0.524
$^{159}Er,^{181}Os$	10	1.913	0.079	0.096

TABLE I: Identical bands in 3qp rotational bands
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bers of the nuclei having the identical bands. For N number of transitions, then $F.C.$ is given as the ratio of total measure of the relative variation in $\Im^{(1)}$ to the relative difference in the moment of inertia due to the variation in mass number of two nuclei.

$$F.C.(A_1) = \left[\frac{1}{N}\sum_{n=1}^{N} F.C._n(A_1)\right] / \left[\frac{A_1{}^{\frac{5}{3}} - A_2{}^{\frac{5}{3}}}{A_1^{\frac{5}{3}}}\right]$$

where n is the label of state. The limit set for F.C. is chosen as less than one for the bands to be identical in ND regime. The parameter R_γ measures the comparison to rigid rotor as it is defined as the ratio of fractional change in γ-ray energies to the fractional change in $A^{\frac{5}{3}}$:

$$R_\gamma = \frac{\Delta E_\gamma\,(J)\,/E_{\gamma 1}\,(J)}{(A_1/A_2)^{\frac{5}{3}} - 1}$$

where A_1 and A_2 ($A_1 > A_2$) are the mass numbers of nuclei, $\Delta E_\gamma\,(J) = E(J) - E(J-1)$ and $E_{\gamma 1}\,(J)$ are the γ-ray energies associated with rotational band of nucleus with mass number A_1. For the bands to be perfectly identical, R_γ should be equal to zero. Thus, smaller the value of R_γ, better will be identicity in the bands. In the present work, we determine the R_γ, $\Delta E_\gamma/E_\gamma$ and $F.C.$ for various nuclei in which high-K rotational IBs are observed as shown in TABLE I.

Acknowledgments

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