Spins of superdeformed rotational bands in $A \sim 190$ mass region

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Introduction

Superdeformed rotational bands are now well established in $A \sim 190$ mass region [1]. Superdeformed (SD) bands in $A \sim 190$ mass region are identified by the dynamic moment of inertia ($\Im^{(2)}$), which rises smoothly with the rotational frequency ($\hbar\omega$). With the advent of large $\gamma-$ray detectors, lower mass regions of superdeformation has been explored. Various SD bands are currently available in $A \sim 190, 150, 130$ and 80 mass regions. Presently, rich variety of data is available about SD bands. The spectroscopic data for SD bands consists of only intraband energies. The unavailability of discrete $\gamma-$transition, linking SD states to normal deformed states makes the unique spin assignment of SD bands tedious. Spins of most of the SD bands has an uncertanity of $\sim 1 - 2\hbar$. SD nuclei are characterized by two types of moment of inertia (MoI) viz. kinematic ($\Im^{(1)}$) MoI and dynamic ($\Im^{(2)}$) MoI. The $\Im^{(2)}$ independence on spin makes it the most explored property of SD bands.

Now-a-days, many theoretical models like Harris ω^2 expansion [2], ab expression [3], variable moment of inertia model [4] etc. are available which provide the reliable spins of SD bands. Here we have the used R-ratio [5] method to establish band head spin of ^{197}Pb in $A \sim 190$ mass region.

Formalism

Two parameter ab formula [3], derived form Bohr Hamiltonian for a well deformed nuclei with small axial asymmetry ($\sin^2 3\gamma \ll 1$) proved to the effective tool in studying the properties of SD bands.

$$E(I) = a\left\{\sqrt{1 + bI(I+1)} - 1\right\}, \quad (1)$$

Kinematic and dynamic moment of inertia is extracted from them as follows

$$\Im^{(1)} = \Im_0\left[1 - \frac{(\hbar\omega)^2}{a^2 b}\right]^{-1/2}, \quad (2)$$

$$\Im^{(2)} = \Im_0\left[1 - \frac{(\hbar\omega)^2}{a^2 b}\right]^{-3/2}, \quad (3)$$

where $\Im_0 = \frac{\hbar^2}{ab}$ is the band head moment of inertia. Therefore, the ratio (R-ratio) is obtained as,

$$R = \sqrt{[\Im^{(1)}]^3/\Im^{(2)}} \quad (4)$$

is independent of spin (I).

Results and Discussion

Since $\Im^{(1)}$ and $\Im^{(2)}$ can be experimentally [6] determined by using observed transition energies, hence R-ratio for various SD bands can be calculated. Now, $\Im^{(1)}$ depends upon the spin assignment hence the R-ratio is independent of spin (I) only when the correct spin assigned to the SD band. However, if the spins of SD bands is shifted even by $\pm 1\hbar$, large variation in R-ratio with I is found and R does not remain constant with I. In the present work, we have confined ourselves in $A \sim 190$ mass region. The R-ratio vs. I plots of ^{197}Pb nucleus is shown in Fig. 1. The band head spin obtained coincides exactly with experimental [1, 7] spins (See Table I).

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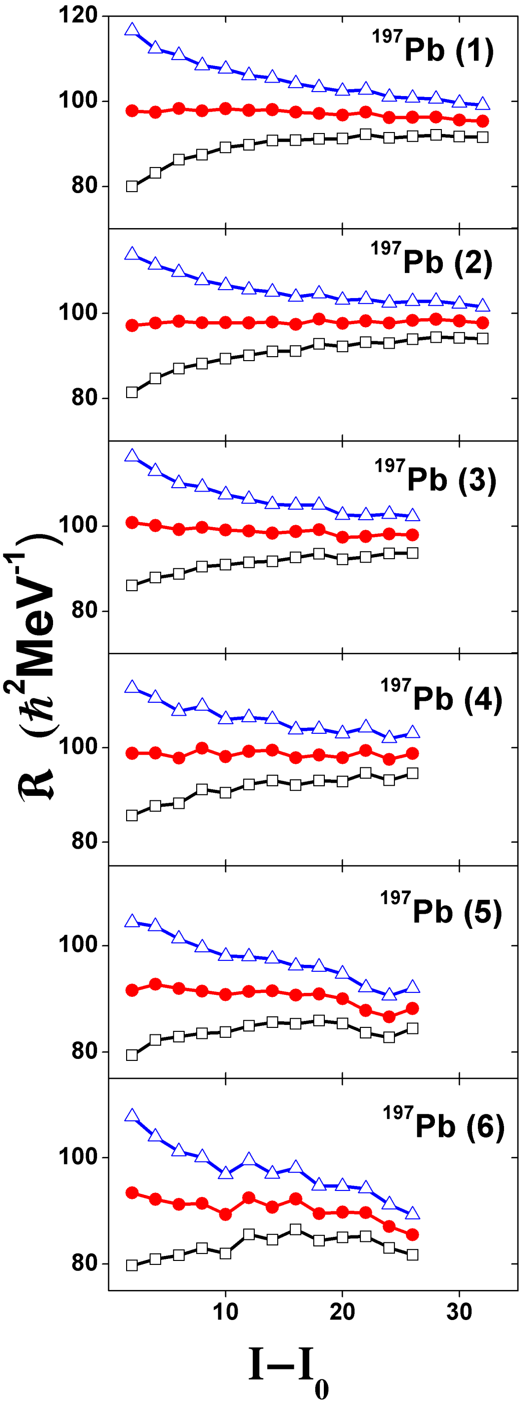

FIG. 1: Variation of R-ratio with $I - I_0$ for various bands in ^{197}Pb.

TABLE I: Band head spin of various SD bands in ^{197}Pb.

SD band	E_γ $(I_0 + 2 \rightarrow I_0)$ keV	I_0 Assigned	Ref. [1, 7]
$^{197}Pb(1)$	123.0	4.5	4.5
$^{197}Pb(2)$	142.6	5.5	5.5
$^{197}Pb(3)$	200.1	8.5	8.5
$^{197}Pb(4)$	221.8	9.5	9.5
$^{197}Pb(5)$	237.5	9.5	9.5
$^{197}Pb(6)$	215.8	8.5	8.5

Conclusion

Band head spin of six SD bands of ^{197}Pb has been assigned using variation of R-ratio with spin. Assigned spins for the lowest levels are $4.5\hbar, 5.5\hbar, 8.5\hbar, 9.5\hbar, 9.5\hbar$ and $8.5\hbar$ for $^{197}Pb(1)$, $^{197}Pb(2)$, $^{197}Pb(3)$, $^{197}Pb(4)$, $^{197}Pb(5)$ and $^{197}Pb(6)$. R-ratio method is proved to be an excellent alternative formula to check the assigned spins of SD bands.

Acknowledgments

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