Lifetime measurements probing nuclear structure issues at high spins in ^{167}Lu and ^{188}Pt

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Introduction

Lifetime measurement for the high spin states focuses on studying nuclear structure features in ^{167}Lu and ^{188}Pt nuclei. The nuclei lying in the rare earth region ($A \sim 165$) have been investigated theoretically and experimentally [1–4] suggesting the observation of normal deformed prolate shape [5] near ground state and triaxial deformed shapes with or without wobbling character [3, 6] at $I \geq 25\,\hbar$ in Lu [1, 2], Hf [7], and Ta [8]. The aim of the present investigation for ^{167}Lu is to know the origin of triaxiality at higher spin and to confirm whether this triaxiality is present at low spins and evolves with spins or introduced due to structural changes taking place at $\nu i_{13/2}$ band crossing is an open question. Also, particle rotor model calculations [4] predict almost no change of triaxiality before and after first $\nu i_{13/2}$ band crossing. For this reason, Q_t measurement are necessary providing a test of axial asymmetry (i.e. triaxiality) and to draw firm conclusion Q_t values must be compared with the values obtained from TRS calculations.

Experimentally different nuclear shape phenomenon like shape coexistence and shape transition [9] in mass $A \sim 190$ has been observed in nuclei ($^{180-190}Hg$ [10], $^{188-194}Pb$ [11], Tl [12] and Au [13]) of this mass region. For Pt with mass $A \sim 190$ [14], the shape coexistence can be given for the nuclear configurations based on different deformations lying at the similar excitation energy while for the shape transition, the nuclei observe varying shapes from one to other as a function of nucleon numbers. The theoretical calculation [15] for mass $A = 172 - 191$ suggest shape transition rather than shape coexistence. The calculations also predicts strongly deformed prolate shapes for low mass Pt nuclei ($172 \leq A \leq 186$) and oblate deformed shapes with some triaxiality for $188 \leq A \leq 194$. It was also predicted through isotopic shift measurements by B. Roussiére *et al.* and J. K. P. Lee *et al.* calculations [16] that ^{188}Pt as the transition point nucleus. Recent spectroscopic measurements [17] tend to support prolate deformed structure in ground state and a sudden change of shape from prolate to oblate due to $\nu i_{13/2}$ neutron pair alignment between $10^+ - 12^+$ state for yrast band.

In the present work, ^{167}Lu and ^{188}Pt nuclei have been investigated to study nuclear structure properties by measuring $B(E2)$ values and related lifetimes using the experimental setup called recoil distance plunger setup present at IUAC, Delhi. From the measured level lifetimes, the reduced transition probabilities (B(E2)) and the transitional quadrupole moments (Q_t) were extracted. The experimental results were compared with the results obtained from Total Routhian Surface Calculations (TRS) done within the framework of Cranked Hartree - Fock Bougliubov model (CHFB)

Experimental Details

In the present work, level lifetimes have been measured for yrast states in ^{167}Lu and ^{188}Pt with the RDM technique. populated using the following fusion evaporation reactions:

- $^{159}Tb(^{12}C, 4n)^{167}Lu$ at beam energy of $74\,MeV$
- $^{174}Yb(^{18}O, 4n)^{188}Pt$ at beam energy of $84\,MeV$

For Lu (Pt) experiment, a thin foil of ^{159}Tb (^{174}Yb) having thickness $\sim 1\,mg/cm^2$ ($\sim 750\,\mu g/cm^2$, made on a thick Ta backing of thickness $\sim 3\,mg/cm^2$ [18]) was used as a target and highly pure Au foil of thickness $\sim 8\,mg/cm^2$ in both experiments was used as a stopper. The data was acquired for different target-stopper distances 14 ranging in between $16 - 2500\,\mu m$ in case of ^{167}Lu (22 in case of ^{188}Pt ranging in between $5 - 10000\,\mu m$). Other details related to these two experiments performed and the related level schemes used in the present work can be obtained from [19, 20]

Results and Discussion

<u>^{167}Lu</u>**:** The lifetimes for the states of interest of populated yrast band have been measured and it was observed that extracted $B(E2)$ values are large and near about constant with increase in spin, indicating the strongly deformed and stable nature for the yrast configuration. The extracted Q_t values obtained in the present experiment are compared with the values calculated from the TRS calculations and with the particle rotor model calculated values before and after band crossing. The experimental values are found to be in close agreement

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*Electronic address: `arohilla8@gmail.com` at deformation parameter $\gamma = 0^\circ$ (calculated using particle rotor model) as shown in Figure 1, suggesting the perfect axial rotor upto the obtained transitions of interest. The present discussion does not completely solve the issue of triaxiality responsible for TSD/wobbling bands at higher spins. This issue can be investigated further by measuring the lifetimes of high spin states beyond first band crossing with Dopper Shift Attenuation Method (DSAM).

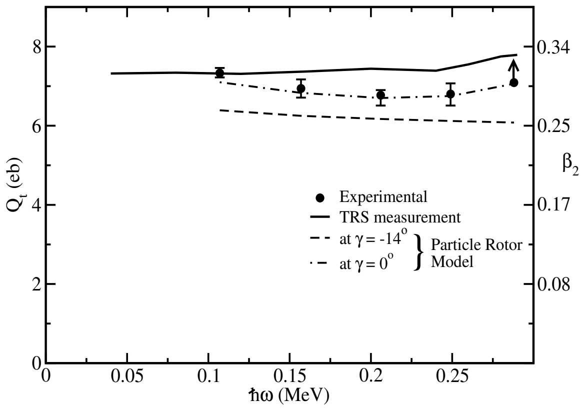

FIG. 1: The comparison of experimentally measured Q_t values with values calculated using TRS and particle-rotor model.

^{188}Pt: The results of the lifetime measurements done for Pt nuclei (A $\leq$ 186) do indicate a decreasing average Q_t values and thus support the theoretical predictions of changing nuclear shapes with increasing mass in Pt - nuclei. For ^{188}Pt nucleus comparison of $B(E2)$ values is shown in Figure 2, average Q_t value is found to be less than the average Q_t value for even $176 \leq A \leq 186$ Pt nuclei stating the loss of axial prolate collectivity toward $A \sim 190$. The TRS calculations predict-

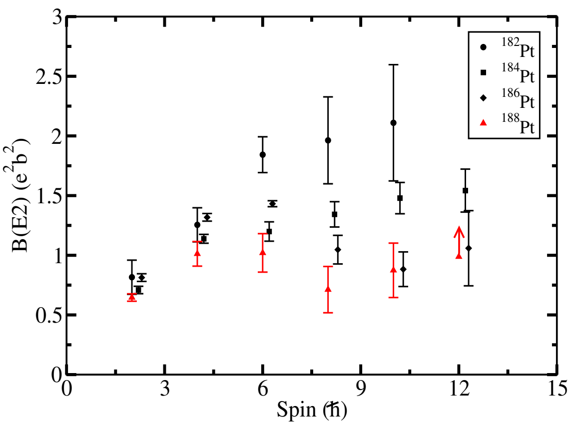

FIG. 2: The comparison of $B(E2)$ values for even-A Pt isotopes.

ing $\gamma \sim 30^\circ$ concludes ^{188}Pt as oblate deformed in ground state and from CHFB calculated values for prolate ($\beta_2 \sim 0.22$) and oblate ($\beta_2 \sim -0.19$), there exists lack of information in making firm conclusion about the shape inversion point. Therefore, RDM measurements are necessary for Pt nuclei with mass $A > 188$ for confirming the issue of inversion point.

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