Nuclear shape evolution near $Z = 82$

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Introduction

The stable Hg and Tl nuclei with proton number around the heaviest known proton and neutron shell closures at $Z = 82$ and $N = 126$ are spherical in shape. This spherical symmetry is broken for the lighter isotopes when the neutron Fermi level lies close to the $\nu_{13/2}$ orbital away from the shell closure. The high-$j$ neutron and the high-$j$ proton orbitals ($\pi h_{9/2}$ and $\nu_{13/2}$) play important roles in determining the shape of the neutron deficient Hg and Tl nuclei. These nuclei in the $A = 180 - 200$ mass region develop shape coexistence, $\gamma$-softness and triaxiality. The interplay of single-particle and collective degrees of freedom induces several interesting phenomena in such nuclei, e.g., magnetic rotation and chirality. Therefore, to make a prediction and to interpret the data on these nuclei, it is important to calculate the nuclear shape and wave function for different quasi-particle configurations.

In this work we performed the model calculations to study the effect of single particle orbitals on the nuclear shape for different configurations, systematically as a function of neutron Fermi level, excitation energy and angular momenta.

Theoretical background

The total Routhian surface (TRS) calculations were performed for the odd-$A$ Hg and Tl isotopes in the mass region $A = 180 - 200$. The quasiparticle energies have been calculated using deformed Woods-Saxon potential with BCS pairing & the total energies are calculated using the Strutinsky shell correction method. The TRSs were calculated for several values of the deformation parameters $\beta_2$, $\gamma$ and $\beta_4$ at different rotational frequency $\hbar \omega$. The $\beta_2$ and $\gamma$ values corresponding to the minimum of the TRS have taken as the deformation of a nucleus. The TRS code of Nazarewicz et al.[1, 2] was used for the calculations. In this code $\gamma = 0^\circ$ correspond to a prolate shape where as $\gamma = \pm 60^\circ$ corresponds to an oblate shape. Any intermediate values of $\gamma$ correspond to a triaxial shape. The detailed procedure has been described in Refs. [3, 4].

Results and Discussion

TRS calculations for odd-$A$ Hg and odd-$A$ Tl isotopes were performed. In case of Hg isotopes the odd-neutron was kept in the positive-parity, positive signature state corresponding to the $\nu_{13/2}$ configuration where as for Tl isotopes the odd-proton was in the negative-parity positive signature, corresponding to the $\pi h_{9/2}$ configuration. The calculated values of $\beta_2$ & $\gamma$ are shown in Fig. 1 &
Before crossing
After crossing
178 180 182 184 186 188 190 192 194 196 198 200 202 204
Mass Number
The results obtained from both TRS and crossing frequency calculations would be discussed, in light of the alignment and hence the nuclear shape change for different nuclei, during the presentation.

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References