# Study of low-spin states of $^{197}$Hg from decay spectroscopy

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## Introduction

The Mercury isotopes (Z=80) are situated in a transitional region, which lies above the region of deformed prolate rare earth nuclei and just below the spherical lead nuclei (Z=82). The low spin structure of odd-A Mercury isotopes with two proton holes with respect to Z=82 shell closure are expected to be dominated by the available single particle neutron orbitals near N=126 shell closure. The heavier Hg isotopes have a small oblate deformation and show various interesting properties. The low-lying negative-parity states in the odd-mass Hg isotopes have been widely addressed using particle-vibration coupling models [1]. On the other hand weakly deformed triaxial shapes have also been indicated in heavier Hg nuclei [2]. Though the first few excited states in odd-A Hg nuclei in mass 190-200 region are explained as core coupled states, but spectroscopic strengths of those states from transfer reactions does not fully support the core excitation model. None of these calculations could reproduce the low lying states of odd-A Hg isotopes accurately. It is thus important to have accurate experimental information of the low lying states of odd A heavier Hg nuclei. In the present work, the low spin structures of $^{197}$Hg, populated by Electron Capture (EC) decay of $^{197}$Tl ($T_{1/2}$=2.84±0.15hrs), have been studied using offline gamma spectroscopy techniques. In the previous decay study [3] of $^{197}$Hg, many of the decay γ-rays are only tentatively placed and feeding to various level could not be determined precisely, which needs to be addressed to understand the structure of low spin excitations in $^{197}$Hg.

## Experiment and Analysis

$^{197}$Tl was populated using 50 MeV α beam from K-130 cyclotron at Variable Energy Cyclotron Centre, Kolkata, bombarded on a self supported gold foil of thickness ~5mg/cm$^2$ following the reaction $^{197}$Au(α,4n)$^{197}$Tl. The irradiated Gold foil was counted offline using an array of four Clover HPGe and two segmented Low Energy Photon Spectrometer (LEPS) detectors. The data were collected in LIST mode using a VME based data acquisition system. 16-channel spectroscopy amplifiers and other standard NIM electronics were used to process the signals from various detectors and setting up logic triggers. Data were recorded in singles and coincidence mode in every 10 minutes to follow the decay half life of various isotopes produced. The coincidence trigger was set as, at least two γ-rays are detected in any two Clover detectors.

The LIST mode data were sorted and calibrated using the known intense γ-rays of Hg isotopes produced. The spectra of all Clover HPGe detectors and LEPS detectors were gain matched to 0.5keV/channel and 0.2keV/channel respectively. To follow the decay of various γ-rays, all the addback spectra of four Clover detectors were added to have total spectra of 10 minutes each. Two 4K x 4K γ- γ matrices were made to confirm the coincidence conditions of various decaying transitions. One matrix was formed with all Clover addback parameters and another matrix was made keeping all segments of LEPS detectors in one axis and all Clover addback parameters at another axis. The other Tl isotopes ($^{198}$Tl and $^{196}$Tl) with comparable half life have also been produced in the present experiment, but with much less cross section (~20 mb), compared to $^{197}$Tl (~1600 mb).

## Results

The origin of various observed γ-rays were obtained by following their decay half-lives. Fig.1 shows decay curves of some of the

transitions in $^{197}$Hg, from which an average half-life of 2.95 ± 0.03 hr has been obtained.

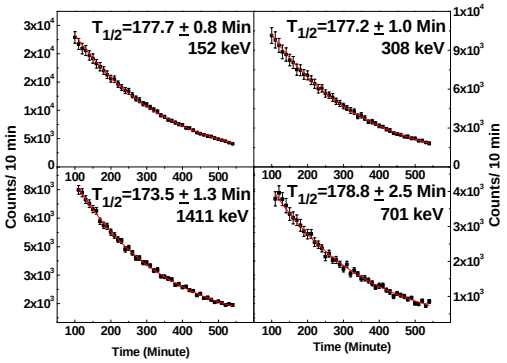


***Fig. 1:*** *Decay curves of few representative transitions in $^{197}$Hg.*

Presence of some of the weak γ-rays, placed tentatively in earlier work [3], could be confirmed from the present γ–γ coincidence data. Fig. 2 shows the coincidence spectrum corresponding to 134 keV, one of the ground state transitions. Almost all the confirmed gamma rays previously assigned to $^{197}$Hg, can clearly be seen from this spectrum.

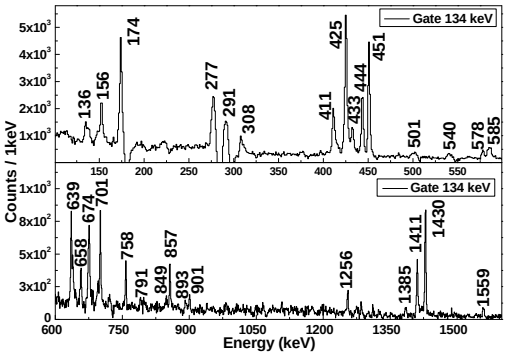


***Fig. 2:*** *Coincidence spectrum of ground state transition 134 keV of $^{197}$Hg.*

The main difficulty in confirming the set of γ-rays of similar energies in $^{197}$Hg is mainly due to the presence of closely spaced excited levels at 308 and 309 keV. The transitions decaying to or originating from these states are very close in energy and difficult to resolve. However, with careful gating condition on various γ-rays, presence of some of the γ-rays could be confirmed from the present work. For example, the 849 keV γ-ray, placed tentatively in earlier work, could be confirmed from the coincidence spectrum of 134 keV, as seen from Fig. 2. The γ-ray doublet of 308 and 309 keV, assigned as the decaying transitions to the ground state from 308 keV (3/2$^-$) and 309 keV (5/2$^-$) excited states respectively, should not be in coincidence with 134 keV transition [3]. But the presence of a 307 keV γ-ray in the coincidence spectrum of 134 keV (Fig.2) confirms its placement as the decaying transition from 892 keV state. The other two new transitions of 411 and 136 keV, observed in coincidence with 134 keV are yet to be placed in the level scheme of $^{197}$Hg. Fig. 3 shows the coincidence spectrum corresponding to 545 keV gate. The 334 and 584 keV γ-rays, placed tentatively in previous work, could be confirmed from this spectrum. The γ-rays marked as '*' in Fig.3 are observed only in the present work and are yet to be placed in the level scheme. The presence of 314 keV and 584 keV γ-rays in coincidence with 545 keV is also clearly visible from Fig.3(b) and (c) respectively and confirmed from the present work. Further analysis is in progress.

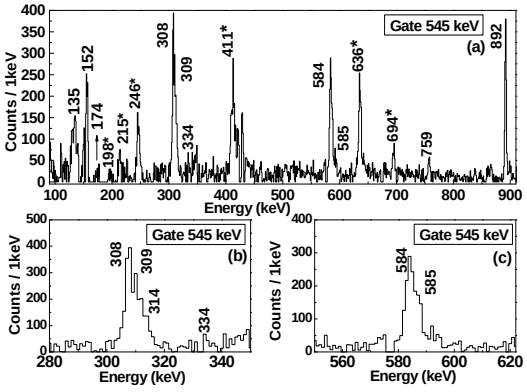


***Fig. 3:*** *(a) Coincidence spectra of 545 keV transition of $^{197}$Hg. (b) and (c) are the same spectrum with expanded view of specific energy region. The γ-rays marked as '*' are the new transitions observed in the present work.*

## References

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