Lifetime measurements in weakly deformed, high-K $h_{11/2}$ band in ^{187}Tl

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Introduction

The region with Z = 82 is abundant in shape coexistence, primarily driven by deformation driving $h_{9/2}$ and $i_{13/2}$ proton orbital's [1, 2]. This phenomenon is evident in even-even mercury isotopes, where there exist coexistence between a slightly deformed oblate ground state and deformed prolate excited state**.** In ^{187}Tl nucleus, Band 3 built upon the $9/2^-$ isomeric state, has a strongly coupled structure similar $9/2^-$ to that seen in the heavier odd thallium isotopes [1,3,4]. On other hand, Band 4 in ^{187}T1 has been tentatively assigned as a strongly coupled band built upon the weakly prolate deformed $11/2^-$ [505] state from the $\pi h_{11/2}$ orbital. This state is predicted to occur at low excitation energy in the equilibrium deformation calculations, and has already been observed in the isotone, ^{185}Au [5]. The 616.9 keV transition is correspond to an allowed M1, $\pi h_{11/2}$ to $\pi h_{9/2}$ transition, consistent with the absence of a measurable lifetime for the $(11/2^-)$ state at 952 keV. Significantly, the interconnecting 616.9 keV transitions could imply separate intrinsic natures for the two bands.

Motivated by these observations, we conduct a lifetime measurement of the de-populating $(11/2^-)$ state in ^{187}Tl nuclei via lifetime measurement using recoil Doppler shift method (RDM) technique at the Inter University Accelerator Center (IUAC), Delhi.

Experimental Details

Low spin excited states in ^{187}Tl were populated via ^{159}Tb (^{32}S, 4n) ^{187}Tl heavy-ion fusion evaporation reaction at beam energy of 154 MeV. The ^{32}S beam was delivered by the 15 UD Pelletron at Inter University Accelerator Center (IUAC), New Delhi. In the experiment a self-supporting target foil of ^{159}Tb of thickness ~ 1.1 mg/cm^2 and a stopper foil of spectroscopically pure gold of thickness 10 ~ mg/cm^2 were properly mounted and stretched on two identical metal cones in the RDM plunger device available at IUAC [6]. For detection of de-excited gamma-rays, the gamma detector array (GDA) [6, 7] detection setup was employed. This detection setup comprised a total of 12 HPGe detectors, these detectors were strategically organized into three separate rings, with four detectors in each ring at an angle of 50^0, 99^0, and 144^0 relative to the beam direction. The data were collected for 22 target-stopper distances (D_{T-S}) ranging from 12 – 10,000 µm. The raw energy spectrum shown in Figure 1, shows the unshifted intensity variation of gamma- ray energy 616.9 keV of Band 4 in ^{187}Tl nucleus at different four target-stopper distances (D_{T-S}) at an angle of 144^0 (backward) with respect to beam direction.

Data analysis

Partial level scheme of ^{187}Tl [8] relevant to present work is shown in Figure 2. For analysis purpose, the observed sharp Gaussian 616.9 keV gamma energy peak (unshifted component), as seen in Figure 1, is fitted nicely in backward angle detectors data at each target-stopper distance.

Following this fitting process, and accounting for efficiency corrections, the intensity at each specific target-stopper distance is obtained. The intensity was then normalized to the intensity of 547 keV gamma energy peak from the Coulomb excitation of gold to yield the normalized intensity of 616.9 keV transition. Subsequently,

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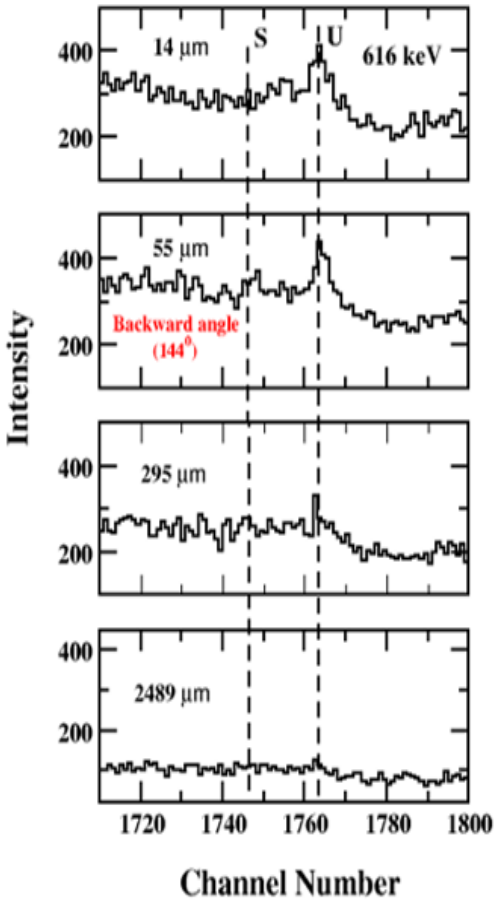

Figure 1: Partial level scheme of ^{187}Tl nucleus relevant to this work. The complete level scheme appears in Ref [8].

E_γ (KeV)	Spin (I_i^π)	Lifetime (ps)	B(M1) (μ_Nx10^{-26})
616.9	11/2$^-$	251.3 ± 19.9	9.19 ±1.64

by employing exponential fitting of normalized unshifted intensity as a function of the target-stopper distance, the mean lifetime of de-populating (i.e., 11/2$^-$ energy state) is obtained. Our analysis yielded a mean lifetime of 251.3 ± 19.9 ps for the 11/2$^-$ state of Band 4 in ^{187}Tl nucleus. Refined result and more comprehensive discussion of data analysis will be done during the presentation later.

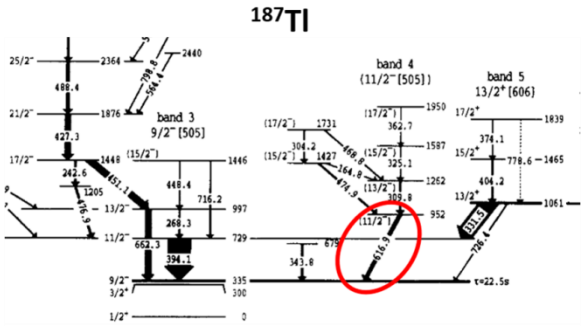

Figure 2: The portion of the raw spectrum showing the 616.9 keV γ-ray transition in ^{187}Tl at a detector angle of 144^0 with respect to beam direction at four target-stopper distances (D_{T-S}).

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