High spin structure and neutron alignments in ^{197}Tl

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Introduction

Odd-A Tl nuclei have spherical ground state based on $3s_{1/2}$ level. Rotational bands, based on excited intruder $\pi h_{9/2}$ and/or $\pi i_{13/2}$ states are also developed in these nuclei. Depending on the neutron number, the neutron pair alignments in Tl nuclei can happen in high-j +ve parity $i_{13/2}$ or low-j –ve parity ($p_{3/2}$, $f_{5/2}$) orbitals. But the high spin data on these nuclei are scarce. Recently, doubly degenerate bands are seen in ^{195}Tl for the 3- and 5- quasi particle configurations [1]. So, it is interesting to study the multi-quasiparticle states in ^{197}Tl. In the previous work of ^{197}Tl [2], a new band was reported which was modified in our previous work [3]. Here we are reporting the new and improved level scheme of ^{197}Tl beyond the neutron alignment in deformed $\pi h_{9/2}$ band and describing its various important features which could not be observed in the earlier works.

Experimental details

Excited states in ^{197}Tl were populated by ^{197}Au(^{4}He, 4n)^{197}Tl reaction. 50 MeV α beam was delivered from K-130 cyclotron at VECC, Kolkata. Experimental details are given in Ref. [3]. To construct the level scheme and for spin parity (J^{π}) assignments of the states, total γ-γ, DCO and polarization (IPDCO) matrices were made with coincidence time window of ±90 ns selected in the prompt peak of γ–γ TAC.

Experimental Results

A new level scheme of ^{197}Tl has been proposed with the placement of 33 new γ-rays in the present work. The partial level scheme is shown in Fig.1. The $\pi h_{9/2}$ rotational band is extended up to $J^{\pi} = 33/2^{-}$ (B1). A new positive parity band B2 has been found and extended up to $37/2^{+}$. Several gated spectra were analyzed to construct the level scheme. Fig. 2 shows spectra gated by previously known 171 keV transition.

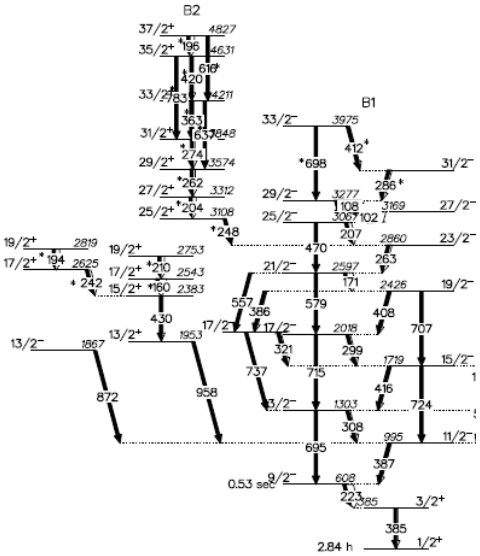

*Fig-1 Partial level scheme of ^{197}Tl proposed from this work; * stands for newly found γ-rays.*

The DCO & IPDCO ratios of 248- and 958-keV γ–rays (IPDCO spectra shown in Fig.3) confirm their E1 nature and hence the +ve parity of band B2 and $J^{\pi} = 13/2^{+}$ for the 1953 keV state, which is interpreted as the $\pi i_{13/2}$ configuration in ^{197}Tl.

Discussion

The level energy vs. angular momentum of band B1 and B2 are shown in Fig. 4. This plot

and the level scheme show that the band B1 attains the 3-qp configuration $\pi h_{9/2} \otimes (\nu i_{13/2})^2$ after $J^{\pi} \sim 17/2^-$ with neutron pair alignment. The +ve parity band B2 emerges just after this alignment. Fitting, by rotational energy formula (shown in Fig. 4) shows that the moment of inertia (MOI) of band B2 is close to that in $\pi h_{9/2} \otimes (\nu i_{13/2})^2$ band, indicating the 3-qp nature of band B2 also.

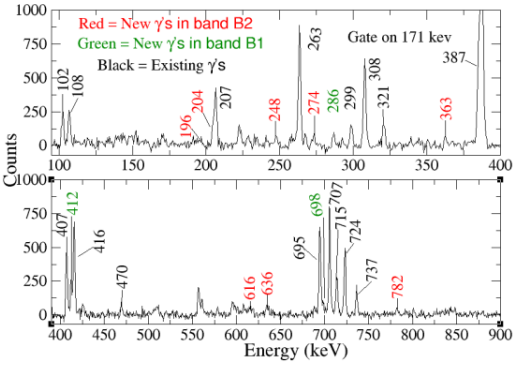

Fig.2: Coincidence spectra gated by 171 keV transition in ^{197}Tl

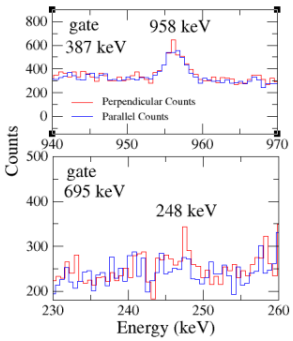

Fig.3: Spectra of perpendicular & parallel scattered counts of 958 and 248 keV γ-rays.

The plot of aligned angular momentum (i_x) vs. rotational frequency ħω of band B2 is analogous to that of the 2-qp 5^- band in ^{194}Hg and ^{196}Hg (shown in the inset of Fig.4). Therefore, a 3-qp configuration of $\pi h_{9/2} \otimes \nu i_{13/2}$ $\nu(p_{3/2}, f_{5/2})$ is assigned to the new band B2 in ^{197}Tl keeping the same semi decoupled neutron configuration of the 5^- band in $^{194,196}Hg$ [4]. The small extra alignment in band B2 may be attributed to the alignment of the odd proton in ^{197}Tl.

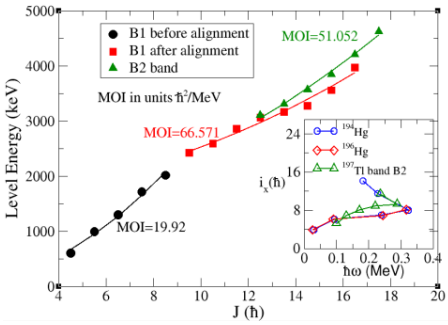

Fig-4 Energy vs angular momentum plot, fitted by rotational formula. (Inset) alignment plot.

The signature splitting of band B1 and B2 are shown in Fig. 5 with angular momentum. In case of band B1 the signature splitting is very prominent and it smoothens out after the neutron alignment. Signature inversion occurs at around 25/2 ħ i.e much after the neutron pair alignment in band B1. Interestingly, the signature inversion in band B1 occurs around the spin region from where the band B2 starts, indicating interaction between these two bands.

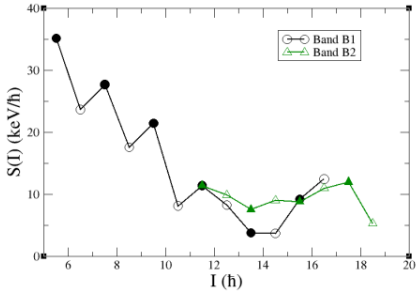

Fig.5 Signature splitting vs. angular momentum for band B1 and B2 in ^{197}Tl.

Two other bands have been observed in this work. One of these bands (3-qp –ve parity) have been extended up to $J^{\pi} = 41/2^-$ ħ.

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References:-

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