Rotational Bands in ^{195}Tl

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Introduction

The proton Fermi level for thallium nuclei (Z=81) lies just below the Z = 82 spherical shell closure. Rotational bands based on the intruder $\pi h_{9/2}$ and $\pi i_{13/2}$ orbitals have been reported with both oblate and prolate deformations for $A < 200$ in Tl isotopes [1–4]. In ^{195,197}Tl [1] the backbending correponding to a pair of neutron alignment is not well studied. Recently an excited state and a new band structure with possible involvement of $\pi i_{13/2}$ have been reported in ^{197}Tl [5], but these are not yet been observed in ^{195}Tl. The $\nu i_{13/2}$ orbital is expected to play important role for backbending of the Tl nuclei with $A \leq 195$ as this orbital becomes 'available' for neutron number $N \leq 114$. Therefore, it will be interesting to study the high spin states in ^{197}Tl. Knowledge of the high spin band structure in ^{195}Tl is very limited [1] and the previous work was carried out using a planar intrinsic Ge detector and two Ge(Li) detectors. Here we are reporting the detailed high spin spectroscopy of ^{195}Tl carried out using *INGA* array.

Experiment and Data Analysis

High spin states of ^{195}Tl were populated in fusion evaporation reaction ^{185,187}Re(^{13}C,xn)^{195}Tl at the beam energy of 75 MeV, obtained from the BARC-TIFR Pelletron-Linac Facility at Mumbai. $\gamma - \gamma$ coincidence data were taken using 15 clover HPGe detectors with BGO anti-Compton shield in Indian National Gamma Array (INGA) at TIFR. Digital data acquisition system was used for acquiring time-stamped data [6]. E_γ-E_γ matrix and E_γ-E_γ-E_γ cube were generated for further analysis. The multi-polarities and type of the γ rays were deduced from DCO and IPDCO ratio analysis as described in [7].

Experimental Results

In the present study 27 new γ lines have been found and placed in the level scheme of ^{195}Tl. The band (B1) based on the $9/2^-$ isomer, corresponding to $\pi h_{9/2}$ configuration, has been extended beyond the band crossing, upto spin-parity $39/2^-$ and excitation energy 5.4 MeV. The band based on $15/2^+$ state has been found out to be $15/2^-$ (B2) from the DCO and IPDCO measurement of the associated γ rays. This band has been extended from $37/2\hbar$ to $45/2\hbar$. A new side band (B3) decaying to B2 band has been observed for the first time in ^{195}Tl.

Discussions

A comparison of aligned angular momenta (i_x) for $\pi h_{9/2}$ bands in ^{193}Tl [8] with ^{195,197}Tl [5] shows a larger gain in alignment for the $N = 114$ nucleus ^{195}Tl than for the $N < 114$ nucleus ^{193}Tl (Fig. 1(a)). Although high spin states are not well known but a similar larger gain in alignment can be clearly seen in ^{197}Tl also. This indicates the involvement of the $\nu i_{13/2}$ orbital for Tl isotopes with $N \geq 114$.

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The kinetic moment of inertia $J^{(1)}$, shown in Fig. 1(b) for all the three isotopes, are similar before the band crossing. After the band crossing, $J^{(1)}$ for ^{195}Tl is slightly more than ^{193}Tl. The $J^{(1)}$ values for the B2 band in ^{195}Tl are very similar to those for ^{197}Tl, indicating similar three quasi-particle configuration for this band in ^{195}Tl as in ^{197}Tl [5].

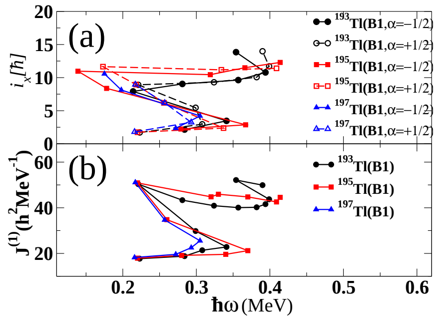

FIG. 1: (a) Aligned angular momentum (i_x) and (b) kinematic moments of inertia $J^{(1)}$ as a function of rotational frequency ($\hbar\omega$) for odd-A Tl isotopes.

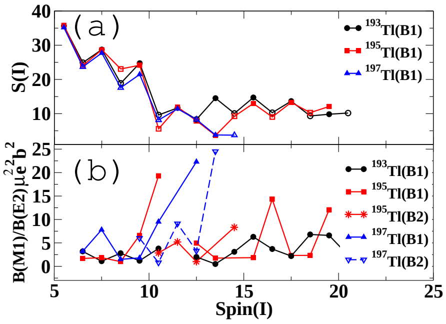

FIG. 2: (a) Energy staggering S(I) and (b) B(M1)/B(E2) ratios as a function of spin (I) for odd-A Tl nuclei.

In Fig.2 the energy staggering S(I) (defined as $S(I) = [E(I) - E(I-1)]/2I$, where E(I) is the energy of a state with spin I) and the experimental B(M1)/B(E2) ratios (obtained from the γ-ray intensities) for $^{193,195,197}Tl$ are plotted as a function of spin. It can be seen that the phase of S(I) remains same for all the three nuclei until band crossing. After the band crossing, the phase of ^{195,197}Tl ($N \geq 114$) changes (signature inversion) while it remains same for ^{193}Tl ($N < 114$). Indication of signature inversion in ^{193}Tl is seen after the second crossing. The B(M1)/B(E2) ratios for ^{195,197}Tl are larger compared to ^{193}Tl in the band crossing region.

Conclusion

High spin states of ^{195}Tl have been studied at *INGA* using ^{185,187}Re(^{13}C,xn)^{195}Tl reaction and a new level scheme with 27 new γ-rays has been proposed. Definite spin and parity assignment were done using DCO and IPDCO measurements. The $\pi h_{9/2}$ band has been extended beyond the band crossing and has been compared with the other Tl isotopes. The positive parity 3-qp band has been extended upto spin $45/2^+$ and a new side band (with a possible 5-qp configuration) has been observed for the first time in ^{195}Tl. Involvement of $\nu i_{13/2}$ orbital for the $N \leq 114$ has been discussed. The details of the experimental results and the discussion will be presented.

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