Lifetime measurement of ^{130}Cs in picoseconds

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Introduction

The doubly odd nuclei around A∼130 exhibit various phenomena and are worth investigating. These nuclei are generally γ-soft because of the presence of low-Ω $h_{11/2}$ proton and high-Ω $h_{11/2}$ neutron orbitals having different shape-driving effects. Rotational states built on the $\pi h_{11/2} \otimes \nu h_{11/2}$ configuration are known in many nuclei ranging from $_{55}$Cs to $_{63}$Eu [1–3]. The low-lying negative parity band often involves $g_{7/2}$ and $d_{5/2}$ orbitals for the valence proton, as seen in the recent study on ^{126}I [4, 5] for the behavior of signature splitting and its inversion.

In ^{130}Cs, R. Kumar *et al.* [6] observed five bands (viz., A, B, C, D & E) showing signature splitting. But, only for two Bands-A and B [7] the measurements of I_γ, R_{DCO} and Δ_{asym} were carried out. Later, Wang *et al.* [8] measured the lifetime of some of the Yrast states (Band A) and its partner (Band B) manifesting chirality. But for Bands C-E [6], no further measurement exists in literature. In the present work, we have attempted to measure the lifetimes of states of Band-E (of Ref. [6]) using Doppler shift attenuation method (DSAM) by observing the lineshapes. In addition, we extracted intensities of many γ-rays, and R_{DCO} values (Table-I) to confirm the tentative spin assignment. Our aim is to study the nuclear structure properties using the reduced transition probabilities extracted from the measured lifetimes.

Experiment & Data Analysis

High spin states of ^{130}Cs were populated *via* the heavy-ion fusion evaporation reaction ^{124}Sn(^{11}B, 6n)^{129}Cs at 70 MeV beam energy delivered by the BARC-TIFR Pelletron-Linac facility. We utilized a self-supporting target foil of ^{124}Sn of thickness ∼2.2 mg/cm^2. Being a thick target, it played the role of both target and backing. The details of the experimental set-up can be found in [9].

The list mode data were initially calibrated using ^{152}Eu and ^{133}Ba sources for energy and efficiency. We created several asymmetric and symmetric E_γ-E_γ matrices. For the DSAM analysis, we utilized the matrices corresponding to detector positions - all *vs.* 23^0, all *vs.* 90^0 and all *vs.* 157^0. The background subtracted spectra were projected by gating above (GTA) and gating below (GTB) the transition of interest. We analyzed the data using the DECHIST, HISTAVER, and LINESHAPE codes by J. C. Wells [10]. The lifetime values for some of the states of Band-E were successfully deduced for the first time. We utilized the appropriate asymmetric matrices for finding R_{DCO} to confirm spins of the states and the symmetric 4k × 4k matrix for the intensity determination

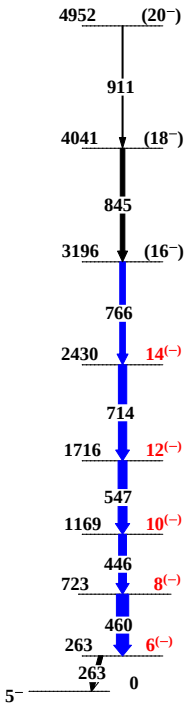

FIG. 1: Partial level scheme of ^{130}Cs with transitions in blue exhibiting lineshapes and spins in red indicating our confirmed spin assignment.

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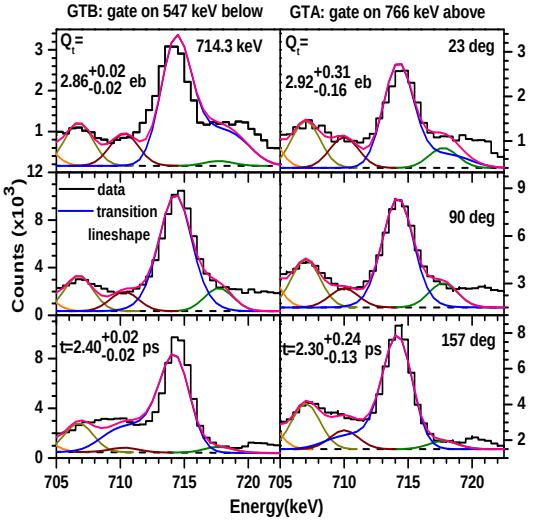

FIG. 2: A typical example, obtained by both GTA and GTB analysis procedures, showing the experimental spectra with lineshape profiles (in blue) for the 714 keV transition. The neighboring contaminant peaks are also shown in different color.

using RADWARE [11] software.

Results & Discussion

We confirmed the spins of the states upto E_x=2430 keV using the R_{DCO} values. However, the bandhead spin was changed to $6^{(-)}$ from (7^-) presented earlier by R. Kumar *et al.* [6]. This was achieved by changing the multipolarity of 263 keV transition. We identified it as a dipole transition consistently by gating on two γ-rays (Table-I) in contrast to reported quadrupole nature [6]. Lifetime measurements have been carried out for the excited states of Band-E using the DSAM technique. We observed the Lineshapes for the transitions of energies (766, 714, 547, 446 and 460 keV) decaying from states with $J^\pi=(16^-)$, $14^{(-)}$, $12^{(-)}$, $10^{(-)}$ and $8^{(-)}$, respectively. A sample of lineshape fitting of 714 keV transition of Band-E with gates above and below, is shown in Fig. 2. The extraction of lifetime of other states is under process.

TABLE I: R_{DCO} values for Band-E.

Gate (keV)	E_γ (keV)	R_{DCO}(err)	Mult.
460	446	1.04(11)	Q
	263	0.69(13)	D
446	263	0.56(7)	D
	460	1.04(7)	Q
	714	0.83(5)	Q
	547	0.82(4)	Q

Conclusion

The present work reports about the preliminary results about spin confirmation & lifetime measurement of some of the excited states of Band-E of ^{130}Cs nucleus. We conjecture the bandhead configuration to be $\pi g_{7/2} \otimes \nu h_{11/2}$ mixed with $\pi d_{5/2} \otimes \nu h_{11/2}$ looking at the neighboring nuclei in A$\sim$130 region [4, 5].

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