Lifetimes of negative parity yrast states in ^{129}Cs

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Introduction

The complex nature of nuclei – with many different structures – poses a challenge in nuclear spectroscopy. In nuclei near mass region 130, the proton Fermi surface lies in the lower part of the $h_{11/2}$ subshell which tends to drive nuclei to prolate shape ($\gamma\sim$ 0°), while the neutron Fermi surface in the middle or upper part of the $h_{11/2}$ subshell tends to oblate shape ($\gamma\sim -60°$) [1].

Measurement of lifetimes of nuclear states constitutes an indispensable probe into the microscopic structure of nuclei. Wang *et al.* [2] measured the lifetimes of the states of ^{129}Cs using a ^{124}Sn thick target with backing, while Sihotra *et al.* [3] established the decay scheme. In the present study, we have extracted the precise lifetimes using a thick target which acted as a backing also. Besides, we have lifetime results for more states in ^{129}Cs compared to previous work [2].

Experimental details

We populated excited states of ^{129}Cs using the heavy-ion fusion evaporation reaction ^{124}Sn(^{11}B, 6n)^{129}Cs at 70 MeV beam energy delivered by the TIFR Pelletron-Linac facility in Mumbai. The target was an isotopically enriched self-supported foil of ^{124}Sn (thickness ~ 2.2 mg/cm^2). We utilized the INGA setup consisting of 21 Compton suppressed clover HPGe detectors at 23°, 40°, 65°, 90°, 115°, 140° and157°.

Data analysis and results

We analyzed the collected triple-γ coincidence data by making symmetric and asymmetric E_γ-E_γ matrices. Three asymmetric matrices - forward (23°) *vs.* all detectors, 90° *vs.* all detectors, and backward (157°) *vs.* all detectors – were utilized in finding the lifetime. We set different energy gates on the asymmetric matrices to observe the lineshapes.

Using the symmetric matrix, we determined the intensities of all the concerned transitions belonging to band B6 and interlinking transitions from B7 and B8 established by Sihotra *et al.* [3], shown in Fig. 1. Also various parameters like, side-feeding intensities, dynamic moment of inertia and branching ratio were calculated. We have used a rotational cascade side-feeding model of five transitions.

Lifetimes of excited states belonging to negative parity $\pi h_{11/2}$ band were measured using the gate on transition above and gate on transition below, and the average values are presented in Table 1. Typical lineshape fitting, performed using the computer code by J. C. Wells [4] *et al.* for two gamma transitions are shown in Fig. 2.

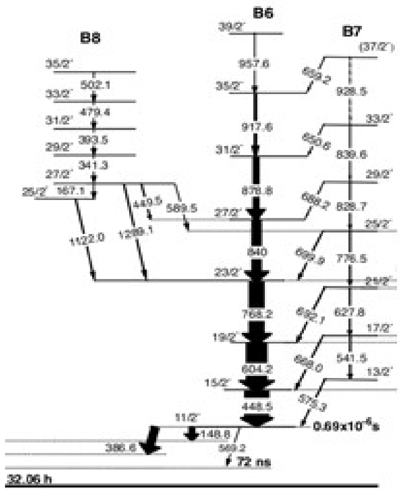

Fig. 1: Partial decay scheme of ^{129}Cs [3]

Table 1: Lifetimes of states built on $\pi h_{11/2}$.

I^{π}	E_{γ} (keV)	τ (ps)
39/2-	957.7	$0.98^{+0.12}_{-0.15}$
35/2-	917.7	$1.74^{+0.19}_{-0.16}$
31/2-	878.8	$1.15^{+0.15}_{-0.14}$
27/2-	840.1	$1.76^{+0.17}_{-0.11}$
23/2-	768.2	$2.07^{+0.13}_{-0.19}$
19/2-	604.2	$2.31^{+0.10}_{-0.11}$
15/2-	448.4	$2.56^{+0.19}_{-0.13}$

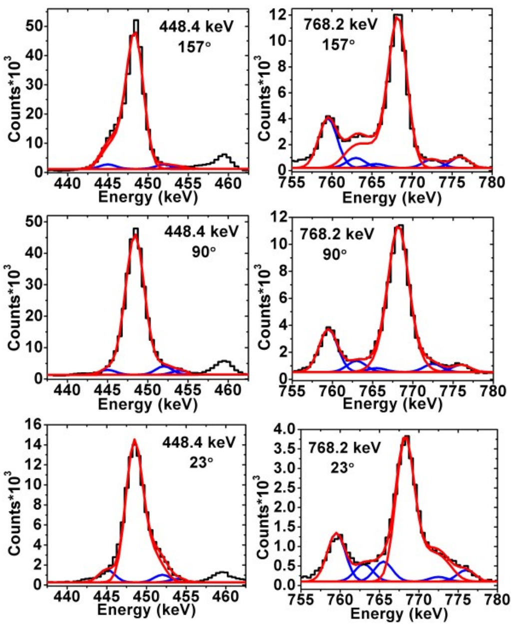

Fig. 2: Transitions of energies 448 (15/2-) and 768 keV (23/2-). Experimental gamma peak and Doppler lineshape fittings are represented in black and red color, respectively; contaminations are in blue.

We used the χ^2 minimization to obtain the best values of transitional quadrupole moment Q_t and lifetime (τ), related by the following expression:

$$\tau = \frac{16\pi\, f_{\gamma}(E2, I \rightarrow I-2)}{61.2\, E_{\gamma}^{5}(I \rightarrow I-2)\, Q_t^2\, CL_{IK}^2}.$$

Where $f_{\gamma}(E2, I \rightarrow I-2)$ is the branching ratio of the E2 transition and CL_{IK} is the Clebsch-Gordan coefficient, written as

$$CL_{IK} = \frac{3}{8}\frac{I(I-1)}{I^2-0.25}\frac{(I^2-K^2)}{I^2}\frac{(I-1)^2-K^2}{(I-1)^2}.$$

Here I and K denote the spin and its projection on the symmetry axis, respectively.

The transitional quadrupole moment decreases (Fig. 3) sharply from spin 7.5 to 13.5, then remains roughly constant with a slight increase at spin 15.5. There seems a shape change at spin 13.5 which is being investigated using particle rotor model. Moreover, a global fit of lineshapes of all the transitions simultaneously is underway. Besides, we are investigating other bands which clearly show the Doppler lineshapes. The results will be presented in the symposium.

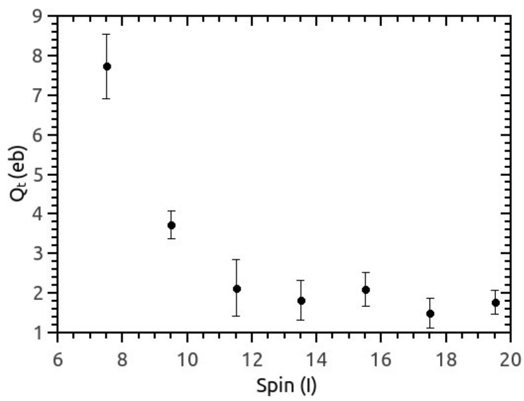

Fig. 3: Measured transition quadrupole moment Q_t as a function of spin for band B6.

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