Lifetime measurements in neutron rich ^{133,135}Xe

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Introduction

The lifetimes and transition probabilities around doubly magic ^{132}Sn are important as they provide information on interaction matrix elements [1, 2]. In particular, the Xe isotopes with a few neutron holes in N = 82 closed shell are interesting as the valence neutrons provide relatively limited number of single-particle configurations with less mixing. These data are essential to generate the testing ground for existing theoretical models.

The structure of Xe nuclei with Z = 54, located within the proton midshell between Z = 50 and Z = 64, are also expected to show the interplay between collective and single particle excitations. The $R_{4/2}$ ratios and the evolution of transition strengths in the even-even Xe isotopes display the transitional behaviour from γ soft rotor [O(6) symmetry, ($R_{4/2}$ = 2.5)] to spherical vibrator [SU(5) symmetry, ($R_{4/2}$ = 2.0)], as one moves towards the neutron shell closure at N = 82 [3].

A very recent measurement proposes the existence of triaxial deformation in odd-A ^{129}Xe [4]. Therefore, systematic study of transition probability in Xe isotopes becomes also crucial to study shape phase transition in Xe nuclei.

However, the low lying structure of odd A isotopes of neutron rich Xe, especially the ones close to N = 82 shell closure, are less studied and therefore, needs to be investigated. Data on lifetimes and transition probabilities are very scanty and to be specific, not available for the majority of low lying levels in Xe nuclei around N = 82.

In the present work, the nuclear level lifetime measurements for low-lying levels of two odd-A Xe nuclei, ^{133,135}Xe has been performed using γ–γ fast timing from the β decay of radio-chemically separated ^{133,135}I fission products [5].

Experiment

The excited states of neutron rich Xe isotopes have been populated through the decay of radio-chemically separated ^{133,135}I ($\tau_{1/2}$ ~ 20h, 6h) fission products, produced with ^{nat}U(α, f) reaction at E_{beam}= 40 MeV from K-130 cyclotron at VECC, Kolkata. The decaying gamma rays from excited states has been detected using VENTURE array [6], which consists of eight fast scintillator $CeBr_3$ detectors, coupled to two Compton supressed Clover HPGe detectors, as shown in Fig. 1. Clover HPGe detectors has been used for cleaner identification of γ-transitions. The pulse processing has been done with NIM electronics and VME data acquisition with high resolution Mesytec ADCs.

Analysis and Results

A TAC range of 50 ns was used in this setup which is suitable for fast timing measurements using Generalized Centroid Difference (GCD) method for the measurement of sub-nano second lifetimes. In GCD method, the difference of experimental centroid positions among the delayed and anti-delayed time distributions (ΔC_{exp}), generated for a particular γ–γ cascade, have been measured with proper background corrections. The centroid differences have been compared with the Prompt Response Difference (PRD) function generated with ^{152}Eu source data. The data analysis for the extraction of nuclear level lifetimes has been carried out using the LAMPS analysis package [7] following the techniques described in Ref. [1,6].

From the present experiment, level lifetimes for 2_1^+ level in ^{132}Xe; $5/2_1^+$, $3/2_2^+$ levels in ^{133}Xe and $5/2_1^+$, $7/2_1^+$ levels in ^{135}Xe have been measured. Measured lifetime value for 2_1^+ level in ^{132}Xe is found to be 6±3 ps which is in very well agreement with existing literature value of

6.1(5)-9.7(30) ps [1]. The results for $5/2_1^+$, $3/2_2^+$ levels in ^{133}Xe and $5/2_1^+$, $7/2_1^+$ levels in ^{135}Xe are new. The $CeBr_3$ - Clover coincidence energy spectrum gathered in the present experiment is shown below in Figure 1.

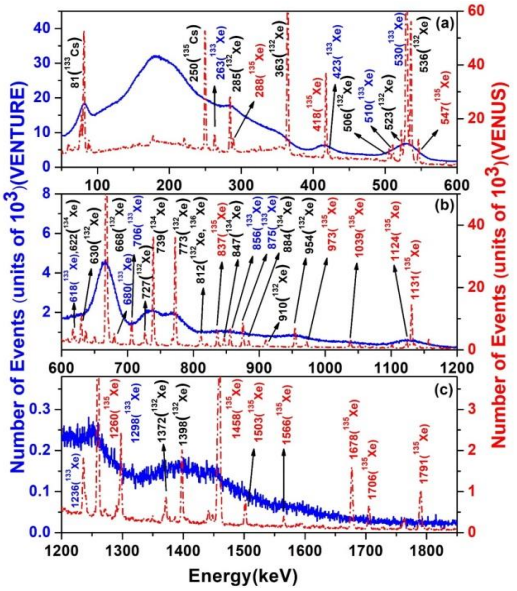

Fig. 1: The total energy spectrum from $CeBr_3$-Clover coincidence.

The gated energy spectrum of 618-680 keV cascade for $3/2_2^+$ level in ^{133}Xe and the corresponding delayed and anti-delayed spectra along with background correction are shown in Figure below.

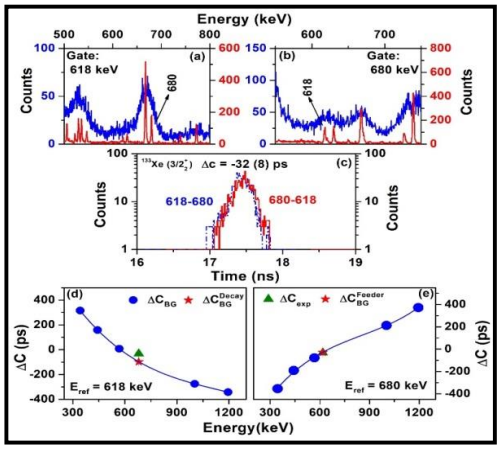

Fig.2: Gated energy spectrum, $CeBr_3$-$CeBr_3$ delayed and anti-delayed TAC for $3/2_2^+$ in ^{133}Xe.

Discussion and Summary

Several new lifetimes for low-lying levels in odd mass ^{133,135}Xe have been measured using GCD method. The reduced transition probabilities B(E2) and B(M1) corresponding to the decay of those low lying levels in *^{133,135}Xe* have been deduced from the measured lifetimes. The experimental results have been compared and interpreted with shell model using NuShellX code. The deduced B(E2) transition probabilities in ^{133,135}Xe are also shown in Fig. 3 in comparison with the neighbouring Xe isotopes around ^{132}Sn. It is observed that the measured B(E2*)* values in the present work globally corroborate with data in neighbouring isotopes and confirms shell closure as one goes towards neutron number N=82.

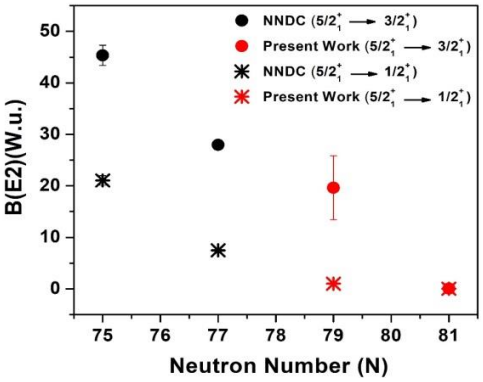

Fig.3: The B(E2) values for odd-A Xe isotopes as function of neutron number.

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