Lifetime measurement in neutron rich nuclei around ^{132}Sn

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Introduction

Measurement of level lifetime gives a direct insight into the structure of any excited nuclear level. Such measurements in the nuclei around ^{132}Sn are of extreme importance in order to understand the two body effective interaction around the double shell closure of Z=50 and N =82. In several nuclei close to this double shell closure, the experimentally determined level energies and quadrupole moments show anomalies when compared with the shell model calculations [1,2]. This anomaly is observed mainly for the levels involving $\pi d_{5/2}$ orbital and there are two different types of explanations found in literature. One of them is the lowering of excitation energy of the $\pi d_{5/2}$ orbital [3] and the other is the change in n-n interaction due to the presence of the neutron skin [4]. Complete information on the lifetime and transition probabilities around ^{132}Sn can help in probing specifically on the later phenomenon. Hence, a program has been taken up at VECC for the systematic study of the low lying level structure of the neutron rich nuclei in this region, by following the decay spectroscopy of radio-chemically separated fission fragments [5,6].

In case of ^{132}I, different values of lifetimes are found in different literature. In our earlier works, the lifetime of the 49 keV, 3^+ state and that of the 161 keV, 2^+ state were measured [5,7]. In case of ^{131}I, level lifetimes are known only for the $5/2^+$, 150 keV level and 1797 keV level which were measured by using slope techniques with NaI(Tl) and plastic scintillators [8]. The lifetime measurement of the 1646 keV and 1899 keV levels in ^{131}I were attempted using the MSCD (Mirror Symmetric Centroid Difference) measurement with $LaBr_3$ detectors [5]. Level lifetimes are known for few low lying levels in ^{132}Xe and these were measured using DSAM (Doppler Shift Attenuation Method) and Coulomb excitation experiments [9]. In ^{131}Xe, the level lifetime for the 80 keV, $1/2^+$ level, which can be accessed through beta decay of ^{131}I, is measured by using Mossbauer spectroscopy [10] and delayed coincidence techniques [11]. The present work reports the measurement of level lifetime for few of the low lying excited levels in ^{131,132}I and ^{131,132}Xe using slope, de-convolution and Generalized Centroid Difference (GCD) techniques.

Experimental Details

Alpha induced fission of Uranium followed by radio-chemical separation was used for the production of n-rich Te nuclei. The decay of these nuclei produces $^{131-134}$I and $^{131-134}$Xe in their decay chain depending on the irradiation time based and the half life values of the parent [6]. The measurements have been done with **VE**CC array for **N**uclear Fast **T**iming and Ang**U**lar Cor**RE**lation studies (VENTURE) [12] consisting of eight 1”x1” $CeBr_3$ detectors. During the present experiment VENTURE was coupled to array of six clover HPGe detectors (VENUS) [13]. The common start fast timing technique was used for the generation of time difference between two detectors of the VENTURE array [12]. The comparative energy spectra obtained with VENUS and VENTURE helped in selection of clean energy gates for the projection of time distributions using $CeBr_3$ detectors of VENTURE array.

Results

The $\gamma-\gamma$ coincidences, as obtained with the VENTURE array, for some of the levels in the Xe and I nuclei are shown in Fig. 1 along with that obtained with VENUS. The time distribution spectra corresponding to different levels in ^{131,132}I and ^{131,132}Xe nuclei are shown in Fig. 2 and 3. In Fig. 2, the results have been given for which the time distribution show long exponential decays indicating lifetime values ~ns (nanosecond). The lifetimes of the corresponding levels have been determined by using slope or de-convolution technique. The lifetimes obtained for the levels in ^{131,132}I and ^{131}Xe are comparable with the literature values.

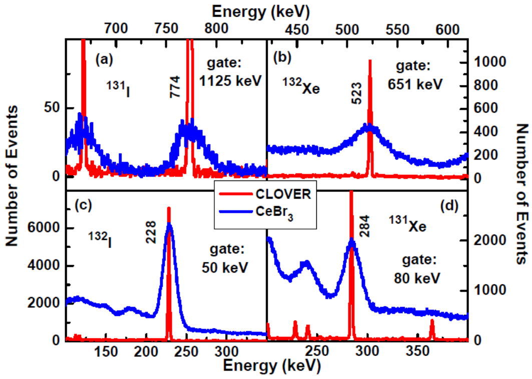

Fig.1: γ–γ coincidence spectra obtained with VENTURE (blue) and VENUS (red) are shown for isotopes of I and Xe.

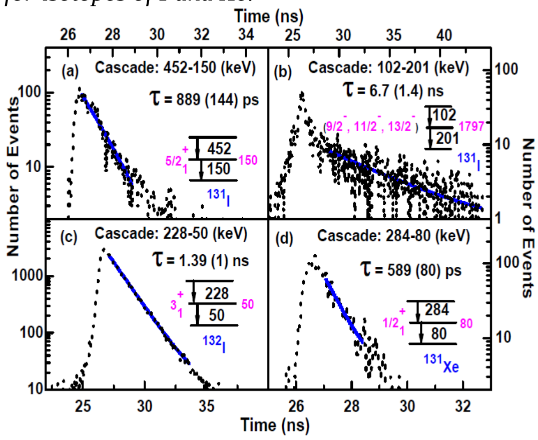

Fig.2: Lifetime measurement of few cascades using slope method.

Fig. 3 shows the delayed and anti-delayed spectra for several low lying levels in ^{131,132}I and ^{132}Xe nuclei, where the lifetime measurements down to few ps (picosecond) are performed using GCD method. The lifetime for some of these levels are measured for the first time and the obtained values range from < 8ps to ~30 ps. Shell model calculation using OXBASH code has been initiated to interpret the experimental data and the results will be presented.

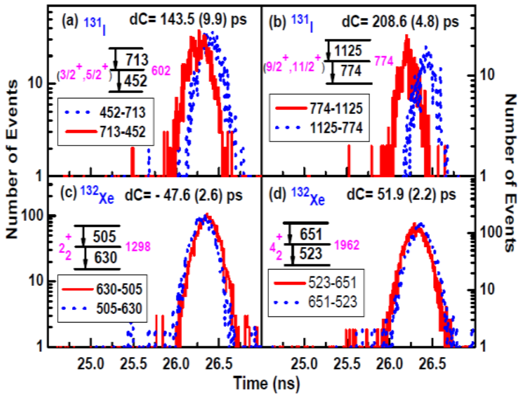

Fig.3: Delayed and anti-delayed time distributions for lifetime measurement using GCD technique.

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