Lifetime measurement of $\frac{11}{2}^-$ isomer in ^{133}La

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Introduction

The lifetime measurement of the $\frac{11}{2}^-$ isomeric state in ^{133}La is the part of the electric quardupole interaction studies in rare-earth metals having twofold aim: (1) to understand the source of electric field gradient in rare earth metals; (2) utilize the information for the nuclear electromagnetic moment measurements of rare earth nuclei. The spectroscopic quadrupole moment measurements in La nuclei, situated in the transitional region between N=66 to N=82, are of vital importance. They exhibit γ-softness, moderate deformation and shape co-existence related to the excitation of the specific pairs of proton or neutron. It is interesting to analyze the configuration dependent quadrupole deformation in this mass region and compare with various theoretical predictions. The available theoretical values found in literature are not in good agreement with the corresponding measurements and convincing themselves [1].

Experimental Details

The $\frac{11}{2}^-$ (E=535.5 keV, $T_{1/2}$ = 62 (4) ns)[2] isomeric state in ^{133}La was populated and aligned in the reaction ^{124}Sn(^{14}N , 5nγ) ^{133}La using ^{14}N pulsed beam with 250 ns time interval at 75 MeV energy from the 15UD Pelletron accelerator facility at the Inter University Accelerator Centre, New Delhi. An isotopically enriched $\sim$500 μg/cm^2 ^{124}Sn backed with 6 mg/cm^2 Au-foil was used as a target. The excited ^{133}La nuclei were recoil implanted into Tb host (thickness $\sim$13 mg/cm^2) to observe quadrupole interaction frequency of the $\frac{11}{2}^-$ isomeric state. The de-exciting γ-rays from the respective isomeric states were detected by two LaBr$_3$(Ce) detectors placed at 0° and 90° in the horizontal plane w.r.t. the beam at a distance of 20 cm from the target. The de-exciting γ-ray spectrum was monitored by a HPGe detector. The partial level scheme of ^{133}La, showing the decay of the presently investigated isomer, is shown in FIG. 1.

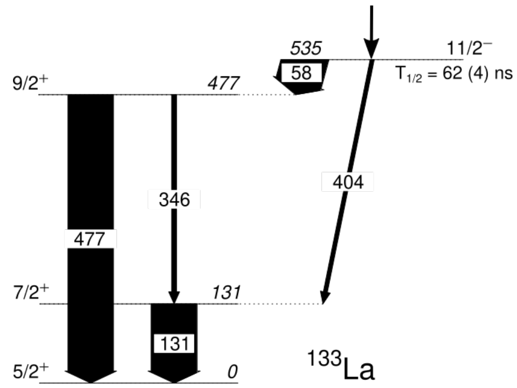

FIG. 1: Partial level scheme showing the decay of $\frac{11}{2}^-$ isomeric state in ^{133}La.

Data Analysis and Results

The data were collected in the LIST mode with four parameters: the two energy and two time signals from the time to pulse height converter corresponding to each LaBr$_3$(Ce) detector. In the offline analysis of the acquired data, following proper gain matching for en-

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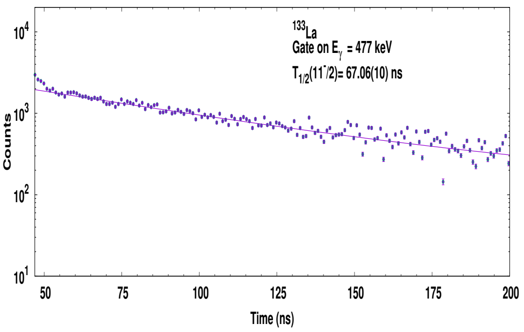

FIG. 2: Lifetime spectrum with energy gate on 477 keV γ-transition from the $\frac{11}{2}^-$ isomeric state in ^{133}La. The solid curve shows the least-squares fit to the data.

ergy and time, two-dimensional matrices of energy versus time were formed for each detector. These matrices were then used to create time-gated energy spectra and energy-gated time spectra for the system.The time spectra of both the $LaBr_3$(Ce) detectors were added after matching the time zero (T_0), normalization and background subtraction. The summed time spectra were LSQ fitted to the exponential decay to extract the half-life of the state. The resulting decay spectra for the $\frac{11}{2}^-$ isomeric state in ^{133}La is shown in FIG. 2.

The observed half-life $T_{1/2}$ ($\frac{11}{2}^-$)= 67.06 (10) ns is in agreement with the results of previous measurements. Further analysis of the data to extract the quadrupole interaction frequency is in progress [3].

The $\frac{11}{2}^-$ isomers in odd mass La nuclei has been observed with energy increasing and half-lifetime decreasing monotonically from ^{125}La to ^{139}La. The $\frac{11}{2}^-$ level is largely $\pi h_{11/2}$ in nature. The reduction of the lifetime with increasing neutron number is a consequence of the hindrances of E1, M1 and M2 transitions and the enhancement of E2 and E3 transitions from the $\frac{11}{2}^-$ level to the lower positive parity states. It has been suggested in the lighter odd-A La isotopes, the E3 enhancement of the $\frac{11}{2}^-$ to $\frac{5}{2}^+$ transition is due to the participation of the octupole vibrations [4]. The change in the E3 transition rate can be attributed to the changing nature of the $\frac{5}{2}^+$ level, i.e., contribution of the $2d_{5/2}$ to the $\frac{5}{2}^+$ level.

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