Quadrupole moment of $\frac{19}{2}^-$ isomeric state in ^{137}La and $\frac{21}{2}^-$ isomeric state in ^{131}La

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Introduction

The nuclei in the $A \sim 130$ mass region are known to be soft with respect to the triaxial deformation, γ and thus are sensitive to the polarizing effect of specific quasiparticle configuration. This can lead to the coexistence of quadrupole structures which can be determined by the configuration of the valence quasiparticles [1–4]. In this mass region, both protons and neutrons can occupy the unique-parity $h_{11/2}$ intruder orbitals which play an important role in driving the nuclear shape. The different deformation driving properties of neutrons and protons lead to either a prolate, oblate or triaxial shape depending on the configuration. The knowledge of the static electric quadrupole moments is very important for elucidating the nuclear structure, as they are providing model independent information on the underlying nuclear shapes. The present work is devoted to the investigation of ratio of the quadrupole moment of the isomeric states with spin-parity $\frac{21}{2}^-$ ($\tau_{\frac{1}{2}}$ = 38ns) in ^{131}La [5] and $\frac{19}{2}^-$ ($\tau_{\frac{1}{2}}$ = 360ns) in ^{137}La [6]. The time differential perturbed angular distribution ($TDPAD$) technique was used for these measurements.

Experimental Details

The isomeric states in ^{131}La were populated and aligned in the reaction ^{116}Cd(^{19}F, 4nγ)^{131}La using 90 MeV ^{19}F pulsed beam at the 15UD pelletron accelerator facility, Inter University Accelerator Centre, New Delhi. An isotopically enriched 1 mg/cm^2 ^{116}Cd backed by 10 mg/cm^2 Terbium foil was used as a target. In case of ^{137}La the isomeric states were populated in the reaction ^{130}Te(^{11}B, 4nγ)^{137}La using 50 MeV ^{11}B pulsed beam. The γ-rays were detected by two LaBr$_3$ detectors positioned at 0° and 90° in a horizontal plane w.r.t the beam at a distance of 20 cm from the target. The data were collected in *LIST* mode with four parameters: the energy and time signals from each LaBr$_3$ detector. The partial level scheme of ^{131}La showing the decay of presently investigated isomer is shown in the Fig.1.

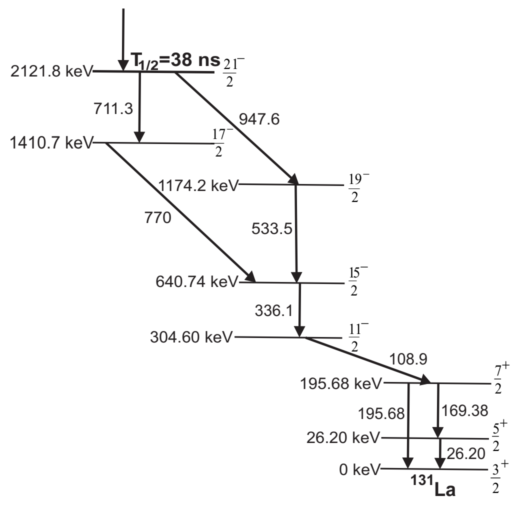

FIG. 1: Partial level decay scheme of $\frac{21}{2}^-$ isomeric state in ^{131}La

Data Analysis and Results

In the off-line analysis of *LIST* mode data, two dimensional matrices of energy versus

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time were formed for each detector. From these matrices time-gated energy spectra and energy gated time spectra were formed. The normalized and background subtracted time spectra of both the $LaBr_3$ detectors were added after matching the time zero (T_0). The summed time spectra were LSQ fitted to the exponential decay to extract the half-life time of the corresponding states. The observed half-life times are in good agreement with the results of the previous measurements [5, 6]. The time spectra corresponding to the delayed γ-rays in ^{137}La and ^{131}La, after-proper background subtraction and normalization, were used to construct the experimental ratio $G_{22}(t)$ [7].

$$G_{22}(t) = \frac{2}{A_{22}} \frac{I(0°,t) - I(90°,t)}{I(0°,t) + 2 * I(90°,t)}. \quad (1)$$

The experimental ratio functions $G_{22}(t)$ for each isomeric state were LSQ fitted to the theoretical perturbation fucntion for two sites in a polycrystalline material [7]. For the $\frac{21}{2}^-$ isomeric state in ^{131}La and $\frac{19}{2}^-$ isomeric state in ^{137}La, the quadrupole interaction patterns are shown in Fig. 2 and Fig. 3 respectively. The quadrupole interaction frequencies obtained are $\omega_0(\frac{21}{2}^-) = 143.6(6)$ Mrad/s and $\omega_0(\frac{19}{2}^-) = 385.5(6)$ Mrad/s. Since efg for La in Tb is not known, the interaction frequencies are used to derive the ratio of spectroscopic quadrupole moments i.e.

$$\frac{Q_s(I = \frac{19}{2}^-)}{Q_s(I = \frac{21}{2}^-)} = 2.18. \quad (2)$$

This factor is independent of efg at the nucleus. Assuming K to be a good quantum number the ratio of the intrinsic quadrupole moments is observed to be

$$\frac{Q_0(I = \frac{19}{2}^-)}{Q_0(I = \frac{21}{2}^-)} = 2.24. \quad (3)$$

Further analysis of data is in progress.

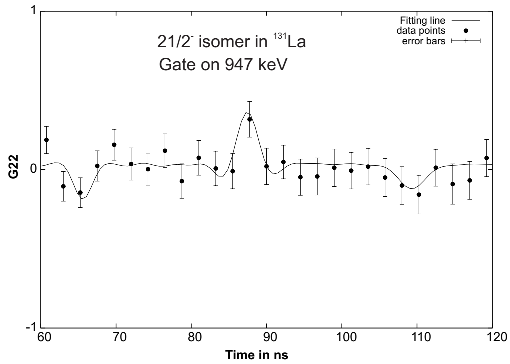

FIG. 2: Quadrupole interaction pattern for $\frac{21}{2}^-$ isomeric state in ^{131}La.

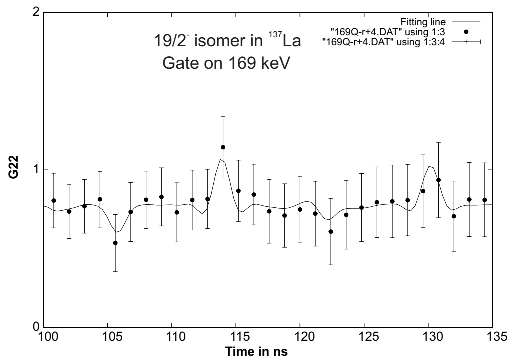

FIG. 3: Quadrupole interaction pattern for $\frac{19}{2}^-$ isomeric state in ^{137}La

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