

Quadrupole moments of $\frac{11}{2}^-$ and $\frac{23}{2}^+$ isomeric states in ^{135}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 $\frac{11}{2}^-$ ($\tau_{\frac{1}{2}} = 10\text{ns}$) and $\frac{23}{2}^+$ ($\tau_{\frac{1}{2}} = 28\text{ns}$) in ^{135}La [6]. The time differential perturbed angular distribution (*TDPAD*) technique was used for these measurements.

Experimental Details

The isomeric states in ^{135}La were populated and aligned in the reaction $^{128}\text{Te}(^{11}\text{B}, 4n\gamma)^{135}\text{La}$ using 55 MeV ^{11}B pulsed beam at the 15UD pelletron accelerator facility, Inter University Accelerator Centre, New Delhi. An isotopically enriched 1 mg/cm² ^{128}Te backed

by 7 mg/cm² Terbium foil was used as a target. The γ -rays were detected by two LaBr₃ 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 LaBr₃ detector. The partial level scheme of ^{135}La showing the decay of presently investigated isomer is shown in the Fig.1.

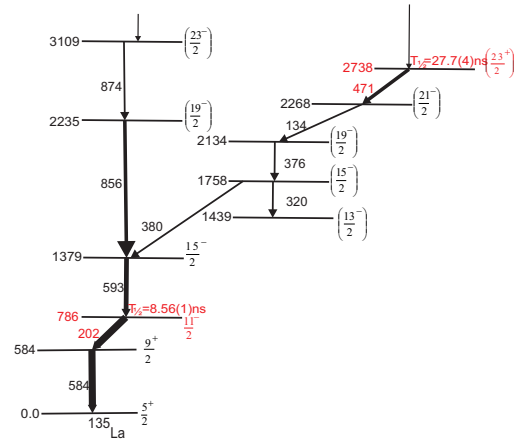


FIG. 1: Partial level decay scheme of $\frac{11}{2}^-$ and $\frac{23}{2}^+$ isomeric states in ^{135}La

Data Analysis and Results

In the off-line analysis of *LIST* mode data, two dimensional matrices of energy versus 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 LaBr₃ detectors were added after matching the time zero (T_0). The summed time spectra were *LSQ* fitted to the

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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 ^{135}La , after proper background subtraction and normalization, were used to construct the experimental ratio $G_{22}(t)$ [7].

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

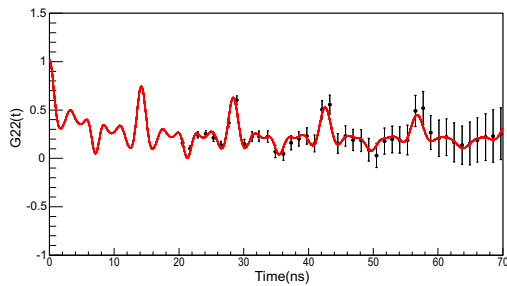


FIG. 2: Quadrupole interaction pattern for $\frac{11}{2}^-$ isomeric state in ^{135}La .

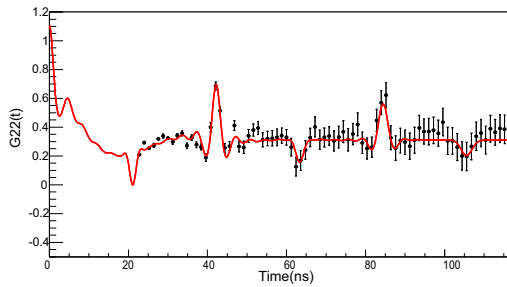


FIG. 3: Quadrupole interaction pattern for $\frac{23}{2}^+$ isomeric state in ^{135}La .

The experimental ratio functions $G_{22}(t)$ for each isomeric state were *LSQ* fitted to the theoretical perturbation function for two sites in a polycrystalline material [7]. For the $\frac{11}{2}^-$ isomeric state and $\frac{23}{2}^+$ isomeric state in ^{135}La ,

the quadrupole interaction patterns are shown in Fig. 2 and Fig. 3 respectively. The quadrupole interaction frequencies obtained are $\omega_0(\frac{11}{2}^-) = 442.6(6)$ Mrad/s and $\omega_0(\frac{23}{2}^+) = 148.7(2)$ Mrad/s. There is no measurement and theoretically calculated value available for the *EFG* at *La* in *Tb* metal or in any other *hcp* metal. In order to extract the information about the relative deformation of the corresponding isomeric states in *La* nuclei the ratios of the spectroscopic quadrupole moments is formed from the fitted quadrupole interaction frequencies. This ratio comes out to be

$$\frac{Q_s(I = \frac{23}{2}^+)}{Q_s(I = \frac{11}{2}^-)} = 1.54. \quad (2)$$

This ratio is free from any uncertainty in the *EFG* at the nucleus. Assuming *K* to be a good quantum number the ratio of the intrinsic quadrupole moments is observed to be

$$\frac{Q_0(I = \frac{23}{2}^+)}{Q_0(I = \frac{11}{2}^-)} = 1.98. \quad (3)$$

Further analysis of data is in progress.

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