g-factors of $\frac{11}{2}^-$ and $\frac{23}{2}^+$ isomeric states in ^{135}La

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Introduction

The transitional nuclei in the $A \sim 130$ mass region with few valence nucleons near shell closure offer to study a variety of shapes and structure, due to the interplay of various multiquasiparticle excitations. The experimental studies based on γ-ray spectroscopy reveals an outstanding high-spin level structure due to the unique parity orbital, $h_{11/2}$ both for protons and neutrons [1]. The study of static nuclear electromagnetic moments is a sensitive test for various theoretical models. The knowledge of the static magnetic dipole moment is very important for elucidating the structure as it provides model independent information on the underlying configurations. In the present investigation, the magnetic perturbation of the angular distribution pattern of the de-exciting γ-rays from the respective isomeric states has been exploited for the calibration of the internal magnetic field at La in iron and for the determination of the g-factor of the isomeric states with spin-parities $\frac{11}{2}^-$ ($\tau_{\frac{1}{2}} < 10$ns) and $\frac{23}{2}^+$ ($\tau_{\frac{1}{2}} = 28.4(8)$ns) in ^{135}La [2]. 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}Te(^{11}B, 4nγ)^{135}La using 60 MeV ^{11}B pulsed beam at the 15UD pelletron accelerator facility, Inter University Accelerator Centre, New Delhi. An isotopically enriched 500 μg/cm^2 ^{128}Te evaporated on 5.7 mg/cm^2 gold foil backed by iron foil was used as a target. The excited ^{135}La nuclei were recoil implanted into the ferromagnetic (Fe) host material. After rolling it to the desired thickness, the 99.99% pure iron foil was annealed [3], to get the saturated internal magnetic field at the recoil implanted La ions. In the second part of the experiment, the $\frac{19}{2}^-$ isomeric state in ^{137}La was excited through ^{130}Te(^{11}B, 4nγ)^{137}La reaction by 55 MeV ^{11}B pulsed beam to calibrate the internal magnetic field at La in Fe. Here, ^{130}Te target was backed by the same annealed iron foil as used in the previous experiment. In these experiments, the iron foil was polarized by 0.2 T external magnetic field perpendicular to the beam-detector plane. The delayed γ-rays from the respective isomeric states were detected by two $LaBr_3$ detectors placed at $\pm 135^\circ$ 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 for each $LaBr_3$ detector. The partial level scheme of ^{135}La showing the decay of the presently investigated isomers is shown in the Fig.1.

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 $LaBr_3$ 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 times of the corresponding states. The observed half-life times are in good agreement with the results of the previous measurements [2, 4]. The time

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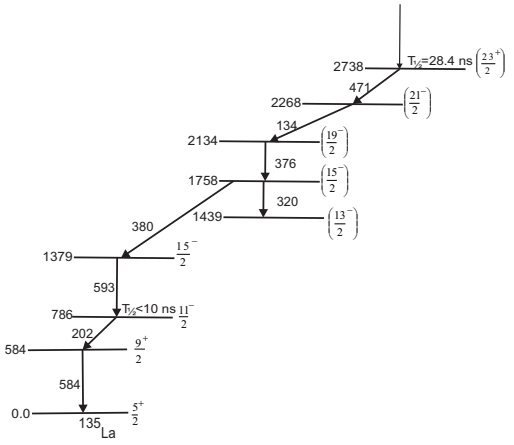

FIG. 1: Partial level decay scheme of $\frac{11}{2}^-$ and $\frac{23}{2}^+$ isomeric states in ^{135}La [2]

spectra were used to form the experimental modulation ratios,

$$R_{exp}(t) = \frac{N(135°,t) - N(-135°,t)}{N(135°,t) + N(-135°,t)}. \quad (1)$$

The ratio factors $R_{exp}(t)$ for the $\frac{11}{2}^-$, $\frac{23}{2}^+$ isomers in ^{135}La and $\frac{19}{2}^-$ isomer in ^{137}La were LSQ fitted to the theoretical magnetic perturbation expression,

$$R_{theo}(t) = A_2 * sin(2\omega_L t + \phi) + \psi, \quad (2)$$

to extract the Larmor precession frequency ω_L ($= g\mu_N B/\hbar$). The angular distribution coefficient A_2, ω_L and phase angle ϕ were kept free parameters. The experimental ratio functions $R(t)$ and the corresponding fits are depicted in Fig. 2. The extracted magnetic hyperfine field at La in Fe from the Larmor frequency of $\frac{19}{2}^-$ state ($g = 0.25(6)$ [4]) in ^{137}La is $22(5)T$. The g-factor values so deduced are $g(\frac{11}{2}^-) = 0.14(3)$ and $g(\frac{23}{2}^+) = 0.11(2)$.

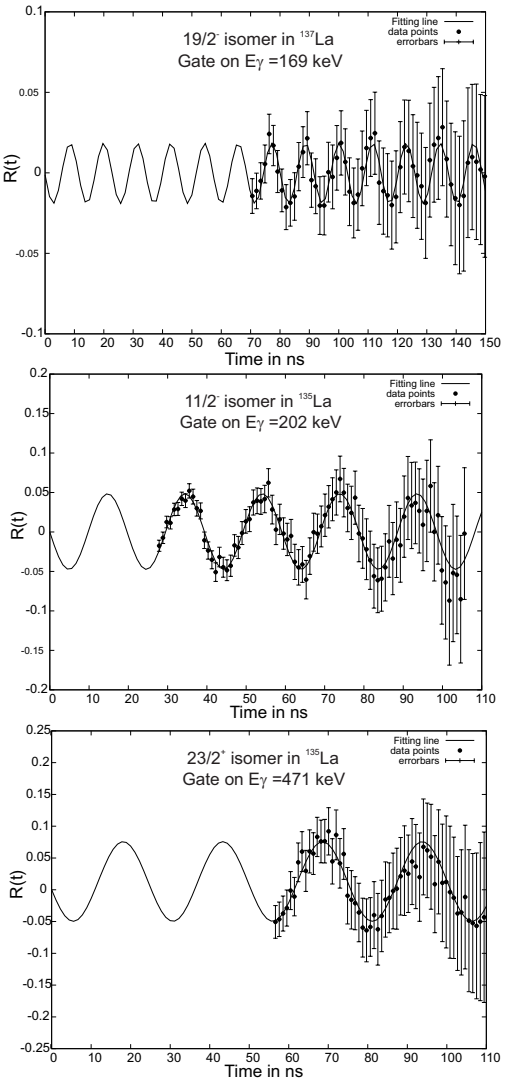

FIG. 2: Spin rotation spectra of the $\frac{19}{2}^-$ isomeric state in ^{137}La and the $\frac{11}{2}^-$ and $\frac{23}{2}^+$ isomeric states in ^{135}La implanted in the polarized Fe at room temperature.

References

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