The time differential perturbed angular distribution(TDPAD) measurement of isomeric state in ^{135}La

S. Saha[1],* R. Palit[1],† S. N. Mishra[1], J. Sethi[1], S. Biswas[1], P. Singh[1], and S. K. Mohanta[1]

[1] *Department of Nuclear and Atomic Physics, Tata Institute of Fundamental Research, Mumbai - 400005, INDIA*

I. INTRODUCTION

Recently, a lot of experimental work have been focused on understanding the nuclear structure near the shell closures. The novelty of these systems are that, a few single particle configurations are available at high spin which can contribute to the total wave function of the state. Hence, these states are relatively pure and the spherical core provides least rotational contribution. The high spin states provide a perfect testing ground for the newly developed large scale shell model calculations.

Nuclei in the vicinity of A $\sim$ 130 region have exhibited a rich variety of collective modes like, shape coexistence and magnetic rotation. A number of high-K isomeric states have also been observed here. Hence the shell structure of this region of the nuclear landscape is of considerable interest. The ^{135}La (Z=57, N=78) nucleus is nearly spherical in the ground state due to its vicinity to $N = 82$ shell closure [1, 2]. The valence proton configurations of the low spin states are expected to be admixture of $g_{7/2}$ and $d_{5/2}$ orbitals. At higher angular momentum, there can be proton excitation to the $h_{11/2}$ orbital. Hence, to ascertain the contribution of the intruder $h_{11/2}$ orbital the wave function of the high spin states are needed to be examined.

The nuclear magnetic moment of a state has contribution from the orbital and spin angular momenta of the unpaired nucleons. Hence, g-factor measurement of an isomeric state can provide the necessary experimental insight to the single particle configuration of the nucleus at high spins. The time differential perturbed angular distribution(TDPAD) measurement is a powerful technique to probe magnetic dipole moment and g-factor of a isomeric states. With this motivation, TDPAD measurement of the $23/2^+$ isomeric state in ^{135}La has been carried out.

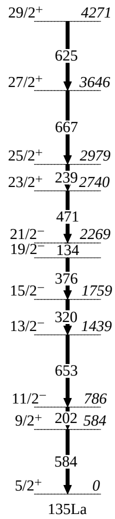

FIG. 1: Partial level scheme of ^{135}La showing the 471 keV decay from a E_i = 2740 keV isomeric state.

---

*Corresponding Author: sudipta.saha@tifr.res.in
†Corresponding Author: palit@tifr.res.in

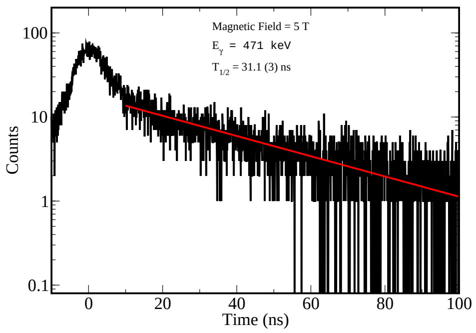

FIG. 2: The time spectrum of 471 keV transition decaying from E_i = 2740 keV isomeric state.

II. EXPERIMENTAL DETAILS

A pulsed ^{11}B beam at 52 MeV was obtained from the TIFR-BARC pelletron accelerator facility. An isotopically enriched ^{128}Te target of 1.02 mg/cm^2 thickness was used to produce excited states of ^{135}La. A gold backing of 200 mg/cm^2 was used to stop the recoil. The cryogenic setup consisted of a superconducting magnet and a temperature controller was used to produce a magnetic field in perpendicular to the beam direction. Four single HPGe detectors were used to record the γ-ray events. The detectors were placed at $\pm 45^o$ and $\pm 135^o$ with respect to the beam direction. The time signal of the HPGe detectors were used as start of time to analog converter (TAC) while the stop signal was provided by electronically delayed primary *rf* buncher. The energy signals were collected with the same trigger condition and for each detector two dimensional TAC-energy matrix was generated. The two dimensional matrices helped to identify the isomeric states of interest. The decay spectra were obtained from the TAC spectrum with gate on the respective γ-rays in the energy spectrum in offline analysis. Different sets of data were taken with 0T, 2T and 5T magnetic field at room temperature.

III. RESULTS AND DISCUSSION

The relevant part of the level scheme is shown in Fig. 1. The spin and parity of the isomeric state is based on reference [2]. The TAC spectrum of a detector placed at 45^o angle with respect to the beam direction with gate on 471 keV γ-ray for the same detector is plotted in 2. An exponential function fitted in the slope region provides the lifetime of the state as $T_{1/2}$ = 31.4(1) ns. Our lifetime estimate is better as compared to reference [2] as the prompt timing of our experiment was only 10 ns as compared to 30 ns in reference [2]. Transverse magnetic field of 0 T, 2T and 5 T have been applied. However, even at 5 T field no significant oscillation of the time spectrum has been observed indicating nearly zero g-factor of the isomeric state. The configuration of the isomeric $23/2^+$ state as proposed in reference [2] is $\pi h_{11/2} \otimes \nu h_{11/2}(s_{1/2}d_{3/2})^1$. The assignment of this configuration is based on systematics. In the present analysis we have assumed the same configuration and approached to determine the mixing of the $s_{1/2}$ and $d_{3/2}$ levels in the isomeric state. The experimental observation of near zero g-factor can be interpreted one neutron particle shared between $s_{1/2}$ and $d_{3/2}$ orbitals with 53.1% and 46.9% respectively. In this calculation standard values of single particle g-factors for different orbitals have been used. No additional admixture from any other configuration has been assumed.

We gratefully acknowledge all the staff of the Pelletron Linac Facility at Mumbai for smooth functioning of the accelerator. The author would like to acknowledge the scientific help provided by S. M. Davane, S. V. Jadhav , R. Dhonti and B. S. Naidu at various times during the experiment.

References

[1] R. Garg et al. Phys.Rev. C **87**, 034317 (2013).

[2] R. Leguillon et al. Physical Review C **88**, 044309 (2013).