g-factor of 9/2^{-} and 23/2^{+} isomeric states in ^{129}Ba

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Introduction

The transitional nuclei in the A~130 mass region with few valence nucleons near shell closure offer to study rich variety of shapes and structures due to interplay of various multi quasi-particle excitations and the collective behavior of underlying core. Many experimental studies based on gamma-ray spectroscopy with heavy-ion-induced reactions evidenced mainly high-spin level structures, an outstanding one being that due to the unique parity orbital $h_{11/2}$ both for protons and neutrons [1]. The different deformation driving forces of the valence protons and neutrons occupying low and high Ω states of the $h_{11/2}$ intruder orbital leads to phenomenon of shape coexistence. With increasing angular momentum, the calculated potential energy surfaces, soft in the γ -degree of freedom, show two distinct minima corresponding to collective prolate and oblate shapes. One of the nuclear models first used to understand the experimental features observed was the particle-triaxial core model, whose application to the Ba isotopes revealed the importance of triaxial deformation in this nuclear region. A sensitive test of the model is the measurement of electromagnetic moments of nuclei. The knowledge of the static magnetic dipole moments is very important for elucidating the structure of coexisting shapes, as they are providing independent information on the underlying configurations. The present work is devoted to the investigation of the magnetic moments for two isomeric states with spin-parities 9/2^{-} ($\tau_{1/2}$ = 14ns) and 23/2^{+} ($\tau_{1/2}$ = 47ns) in ^{129}Ba [2].

Experimental Details

The isomeric states in ^{129}Ba were populated and aligned in the ^{120}Sn(^{12}C,3n)^{129}Ba reaction using 52 MeV ^{12}C pulsed beam with repetition period of 250 ns delivered by the 15UD Pelletron accelerator facility at Inter-University Accelerator Centre, New Delhi. The time differential perturbed angular distribution (TDPAD) technique was used to observe the precession of the intensity distribution of the delayed γ-rays. The excited ^{129}Ba nuclei were recoil implanted into the ferromagnetic (iron) host material. The internal magnetic field in iron was calibrated though the known g-factor of 10^{+} ($\tau_{1/2}$= 14ns, g = -0.159) isomeric level in Ba^{132} [3] i.e. B_{in} = 66 kG. The target was placed between the pole tips of an electromagnet. A magnetic field B = 2 kG was applied perpendicular to the beam-detector plane to polarize the iron foil. The γ-rays were detected by two HPGe detectors and two NaI(Tl) detectors placed at ±45° and at ±135° to the beam direction, respectively.

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 partial level scheme of ^{129}Ba showing the decay of the presently investigated isomers is shown in the Fig.1. For the 9/2^{-} state the 173 keV isomeric transition was analyzed, while in the case of the 23/2^{+} isomer the analysis was done for the 473 keV and 779 keV transitions. The gamma gated time spectra after proper background subtraction and matching T_0 have been least squares fitted assuming an exponential decay. The half-lives for both the states were in agreement with the previous reported values.

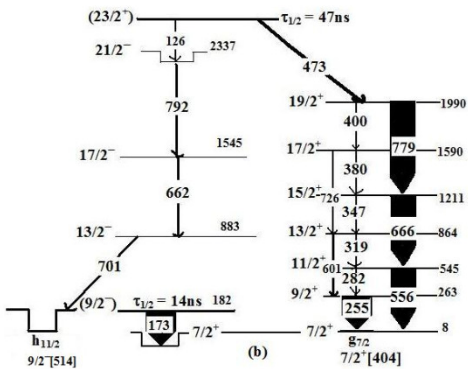

Fig.1. Partial level scheme of the $9/2^-$ and $23/2^+$ isomers in ^{129}Ba.

After proper normalization, the time spectra were used to form the experimental modulation ratios $R_{exp}(t)$

$$R_{exp}(t) = \frac{N_1(t) - N_2(t)}{N_1(t) + N_2(t)}$$

which were least squares fitted to the theoretical function,

$$R_{theo} = \frac{3}{4} A_2 \cos 2\,(\Phi - \omega_L t),$$

where A_2, ω_L and Φ are the angular distribution coefficient, Larmor frequency and the phase angle, respectively. The modulation functions for the 173 keV and 473keV transitions detected by HPGe detectors are shown in Fig. 2 & Fig. 3. From the least squares analysis of these modulation curves, the extracted values of g-factor from the Larmor precession frequencies are,

$g(9/2^-) = -0.19$,
$g(23/2^+) = -0.2$

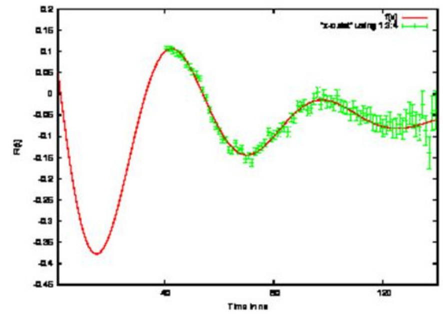

FIG.2. The least-square fitted modulation ratios for the 173 keV transition from the $9/2^-$ isomeric state in ^{129}Ba.

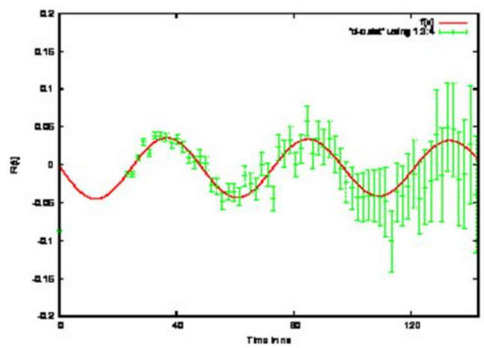

FIG.3. The least-square fitted modulation ratios for the 473 keV transition from the $23/2^+$ isomeric state in ^{129}Ba.

Discussion

From the in-beam gamma-ray studies the $9/2^-$ isomeric state is assigned the configuration $\nu 9/2^-[514]$ and $23/2^+$ isomeric state is considered to be the coupling of the two quasi-particle neutron state 7^- ($\nu 7/2^+[404] \otimes 7/2^-[523]$) in ^{128}Ba with $\nu 9/2^-[514]$ in ^{129}Ba. The observed g-factor values are in confirmation of the configurations for the $9/2^-$ and $23/2^+$ isomeric states. Further analysis of the data is in progress.

References

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