EPJ Web of Conferences **66**, 02058 (2014)
DOI: 10.1051/epjconf/ 201466602058


# g-factor of the $7^-$ isomeric state in $^{128}$Ba

Jasmeet Kaur[1,a], N. Bansal[1], Vijay R. Sharma[2], H. Kumar[2], R. Kumar[4], V. Kumar[3], A.K. Bhati[1], and R.K. Bhowmik[4]

[1] *Centre for Advanced Studies in Physics, Panjab University, Chandigarh-160 014, India*
[2] *Department of Physics, A.M. University, Aligarh - 202 002, India*
[3] *Centre for Medical Physics, Panjab University, Chandigarh-160 014, India*
[4] *Inter-University Accelerator Centre, JNU Campus, New Delhi-110 067, India*

**Abstract.** The time differential perturbed angular distribution technique ($TDPAD$) has been used to measure the $g$-factor of the 2396 keV, $7^-$ isomeric state in $^{128}$Ba. The measured value of $g(7^-)$ is about 80% higher than the value for the expected configuration of the state.

## 1 Introduction

The even-even nuclei in the A $\sim$ 130 mass region exhibit interesting nuclear structure characteristics e.g. $\gamma$-softness, triaxiality etc. The high spin structure is dominated by rotational bands: an important feature here is the observation of two nearly degenerate s-bands crossing the ground state band [1], which shows prolate character for protons and an oblate character for neutrons. The aligned quasiparticles influencing the shape of the nucleus results in coexisting shapes for different intrinsic excitations. The neutron deficient even-even *Ba* isotopes exhibit collective properties which are good examples of the $O(6)$ symmetry of $IBA$. Further, the presence of high-$\Omega$ orbital near the Fermi level favours the occurrence of $K$-isomeric states [2]. The electromagnetic transitions from higher $K$ to lower $K$ are forbidden and the high $K$ state becomes isomeric. The observation of '$K$-forbidden' transitions provide the testing ground for the various mechanisms of approximate conservation of $K$ quantum number [3]. Very few nuclear moment measurements have been carried out in this mass region and this is the first time that the g-factor of a $7^-$ isomeric state in $N = 72$ isotonic chain has been measured in any investigation.

The $K^\pi = 7^-$, 2396 keV isomeric state in $^{128}$Ba has tentatively been assigned to a two quasineutron configuration through in-beam $\gamma$-ray spectroscopy. The half life, $T_{1/2} = 6.1\,(2)$ ns, of the $7^-$ state is in a range that allows the observation of the precession pattern employing the $TDPAD$ technique. The excited $^{128}$Ba nuclei were recoil implanted into a $Fe$ foil to observe the perturbation of the angular distribution pattern of the de-exciting $\gamma$-rays due to magnetic interaction. The internal magnetic field, $-6.0\,(2)$ T, at *Ba* in iron was calibrated [5] with respect to the g-factor, $-0.159\,(5)$, of the $10^+$ isomeric state in $^{132}$Ba [4].

[a] e-mail: meetu_a@yahoo.co.in

## 2 Experimental details

The partial level scheme showing the decay of the $7^-$ isomeric state is illustrated in Fig.1 [6]. The state of interest in $^{128}$Ba is populated and aligned through the $^{12}$C($^{120}$Sn, 4n) reaction using a 62 MeV, $^{12}$C pulsed beam at the 10UD Pelletron accelerator facility, IUAC (New Delhi). The pulse repetition period was 250 ns. The target consisted of 500 $\mu g/cm^2$ $^{120}$Sn evaporated on a 1 $mg/cm^2$ thick *Fe* backing to stop the recoiling *Ba* nuclei. After rolling it to the desired thickness, the 99.99% pure iron foil was annealed [7], to get the saturated internal magnetic field at the recoil implanted *Ba* ions. Part of the same foil was used for the calibration of the internal magnetic field at *Ba* in *Fe* [5]. The target was placed between the pole tips of an electromagnet to polarize the iron foil by a 0.2 T external magnetic field perpendicular to the detector plane. The $\gamma$-rays were detected by two high-purity germanium (*HPGe*) detectors. The detectors were positioned at ±45° with respect to the beam direction at 25 cm distance from the target in the horizontal plane. The data was collected in list mode recording the energy and the signal w.r.t the beam pulse from a time-to-amplitude converter (TAC) for each *HPGe* detector.

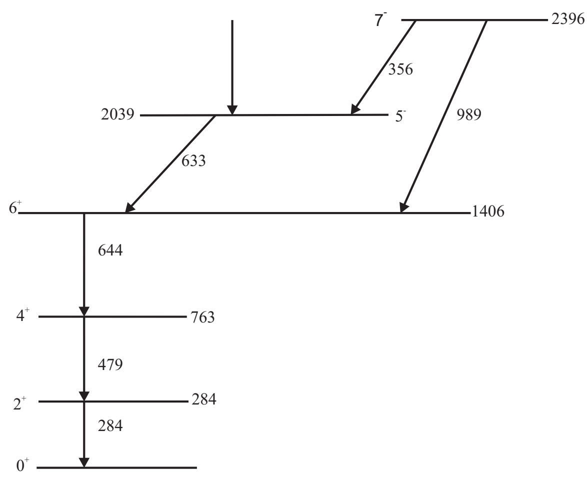


**Figure 1.** Partial level decay scheme of the $7^-$ isomeric state in $^{128}$Ba.

## 3 DATA ANALYSIS

For the off-line analysis of the 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 perturbed angular distribution pattern results in a time dependent modulation of $\gamma$-ray intensities. From the measured intensities at the respective angles, the normalized ratio factor,

$$R(t) = \frac{I(45^\circ, t) - I(-45^\circ, t)}{I(45^\circ, t) + I(-45^\circ, t)}, \tag{1}$$

was formed and least squares fitted to the theoretical function

$$R_{theo} = \frac{3}{4} A_2 * exp(-\lambda * t) * sin(2\omega_L t + \phi), \tag{2}$$

to extract the Larmor precession frequency, $\omega_L$. The anisotropy of the $\gamma$-ray angular distribution, $A_2$, the phase, $\phi$, for the bending of beam and the damping constant, $\lambda = (\frac{1}{\tau_{rel}})$ were kept free parameters. The experimental ratio function $R(t)$ and the fitted curve are shown in Fig.2 for 989 keV delayed transition.

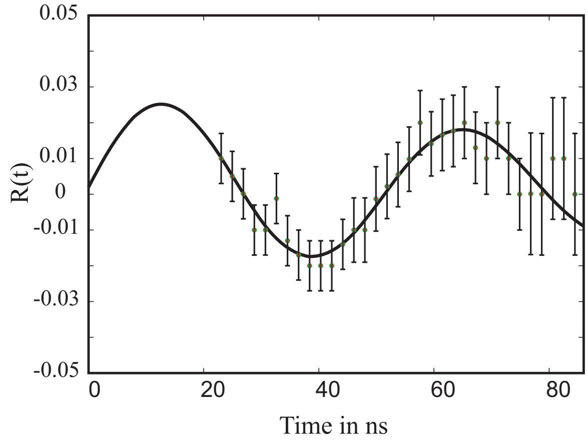


**Figure 2.** Spin rotation spectra of the $7^-$ isomeric state in $^{128}$Ba.

## 4 Results and Discussion

The g-factor of the isomeric state is extracted by taking the ratio of the precession frequency of the $7^-$ state with respect to $10^+$ state in $^{132}$Ba,

$$\frac{\omega_L(7^-)}{\omega_L(10^+)} = 1.21 \pm 0.01, \tag{3}$$

which is free from any uncertainty of the magnetic field value at *Ba* in *Fe*. K. Schiffer *et.al* have adopted the $\nu h_{11/2} g_{7/2}$ (g = – 0.03) configuration for intra-band $\gamma$-ray transition analysis and compared the branching ratio with the rigid rotor calculation for the band built on the $K = 7^-$ isomeric state. The measured value is ~ 80% higher than the adopted one and also different in sign. This clearly shows that the configuration of the state does not correspond to the pure two quasineutron configuration. The possibility of $K$-mixing in this isomeric state has been pointed out by in-band analysis [6], suggesting an admixture of the low- $K$ configuration, $\pi h_{11/2} d_{5/2}$ into the $\nu h_{11/2} g_{7/2}$ configuration.

## References

[1] R. Wyss, A. Granderath, R. Bengtsson, P. von Brentano, A. Dewald, A. Gelberg, A. Gizon, J. Gizon, S. Harissopulos, A. Johnson, et al., Nucl. Phys. A 505, 337 (1989).

[2] A. Granderath, P.F. Mantica, R. Bengtsson, R. Wyss, P. von Brentano, A. Gelberg, and F. Seiffert, Nucl. Phys. A 597, 427 (1996).

[3] P.M. Walker and K. Schiffer, Z. Phys. A 338, 239 (1991).

[4] P. Das, R.G. Pillay, V.V. Krishnamurthy, S.N. Mishra, and S.H. Devare, Phys. Rev. C 53, 1009 (1996).

[5] Jasmeet Kaur, A. K. Bhati, N. Bansal, V. Kumar, Vijay R. Sharma, H. Kumar, R. Kumar, and R. K. Bhowmik, Phys. Rev. C 87, 064312 (2013).

[6] K. Schiffer, A. Dewald, A. Gelberg, R. Reinhardt, K.O. Zell, Sun Xiangfu and P. Von Brentano, Nucl. Phys. A 458, 337 (1986).

[7] P. Maier-Komor, K.H . Speidel, and A. Stolarz, Nucl . Instr. and Meth. A 334, 191 (1993).