R_{DCO} and Polarization measurements in ^{133}Ba

K. Rojeeta Devi[1],* R. Palit[2], Naveen Kumar[1], Neelam[1], P. Singh[2], S. Saha[2], S. Biswas[2], F. S. Babra[2], Md. Sazedur R. Laskar[2], S. Samanta[3], S. Das[3], and Suresh Kumar[1]

[1] *Department of Physics and Astrophysics, University of Delhi, Delhi-110007, INDIA*

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

[3] *UGC-DAE Consortium for Scientific Research, Kolkata - 700098, INDIA*

Introduction

It is well known that the nuclei in A $\sim$ 130 mass region are γ soft. In this mass region, the proton fermi level is located in the lower part of high j $h_{11/2}$ sub-shell and the neutron fermi level is located in the upper part of high j $h_{11/2}$ sub-shell. Because of this shape driving effects, the nuclei in this mass region are expected to show many interesting nuclear phenomena such as magnetic rotation, chiral rotation, shape co-existence, etc [1]. Therefore, such phenomena are also expected in the odd neutron ^{133}Ba nuclei. Previously, high spin states in ^{133}Ba had been investigated using the reaction ^{124}Sn(^{13}C, xn)$^{137-x}$Ba. But, the above important phenomena were not explored in this nuclei and the spin parity of most of the transitions were assigned tentatively [2]. An experiment was performed to re-investigate ^{133}Ba, in which high spin states were populated through the reaction ^{124}Sn(^{13}C, 4n)^{133}Ba. In the present paper, a part of the study was reported in which the multi-polarity of some of the transitions were confirmed and the multi-polarity of two γ- ray transitions were assigned from the Directional Correlation of Oriented State ratio R_{DCO} [3] and polarization asymmetry measurement [4]. The R_{DCO} value was calculated by using the expression,

$$R_{DCO} = \frac{I^{\gamma_1} \text{ at } \theta_1 \text{ (gate on } \gamma_2 \text{ at } \theta_2)}{I^{\gamma_1} \text{ at } \theta_2 \text{ (gate on } \gamma_2 \text{ at } \theta_1)} \quad (1)$$

The polarization asymmetry was calculated from the expression,

$$\Delta = \frac{a(E_\gamma)N_\parallel - N_\perp}{a(E_\gamma)N_\parallel + N_\perp} \quad (2)$$

$$\text{and,} \quad a(E\gamma) = \frac{N_\parallel(unpolarized)}{N_\perp(unpolarized)})$$

Experimental Details

High spin states of ^{133}Ba were populated by using the reaction ^{124}Sn(^{13}C, 4n)^{133}Ba at a beam energy of 48 MeV, provided by the Pelletron Linac Facility at Tata Institute of Fundamental Research (TIFR), Mumbai. The target used was ^{124}Sn of thickness 1.5 mg-cm^{-2} with a backing of 6.0 mg-cm^{-2} thick ^{197}Au. The γ-rays were detected by using the INGA spectrometer [5] which consisted of 3, 3, 1 and 4 number of clover detectors at 157°, 140°, 115° and 90° with respect to the beam direction, respectively, at the time of the present experiment. The asymmetric matrices for R_{DCO} and polarization asymmetry measurements were created by sorting the data using MultipARameter time-stamped based COincidence Search program (MARCOS) and the matrices were analyzed by using RADWARE software [6].

Results and Discussions

The Directional Correlation of Oriented State ratio, R_{DCO} were obtained by taking the events detected at 157° clover detectors on one axis and the events detected at 90° clover

*Electronic address: rojee29@gmail.com

detectors on the another axis. The polarization asymmetry, Δ of the $\gamma-$ray transitions were measured for the first time in the present work. The obtained R_{DCO} along with Δ and the multi-polarity of the $\gamma-$ray transitions are given in TABLE I.

TABLE I: γ-ray energy E_γ, R_{DCO}, polarization asymmetry Δ and the multi-polarity for the γ-ray transitions in ^{133}Ba. Q (Quadrupole) and D (Dipole) denotes the multi-polarity of the gating transition in the determination of R_{DCO}.

E_γ (keV)	R_{DCO}	Gate	Δ	Multi-polarity
321.3	1.07(6)	D	-0.01(4)	M1[a]
338.6	0.92(6)	D	-0.02(2)	M1[a]
458.0	0.24(2)	Q	-0.01(2)	M1+E2[b]
613.6	0.26(2)	Q	0.02(1)	M1+E2
627.3	0.17(1)	Q	0.01(2)	M1+E2
641.9	2.18(17)	D	0.07(8)	E2
680.7	1.06(5)	Q	0.07(1)	E2
743.8	0.25(2)	Q	-0.03(2)	M1+E2
812.0	0.20(2)	Q	0.03(2)	M1+E2[a]
890.1	0.95(5)	Q	0.05(1)	E2
971.5	1.05(9)	Q	0.10(3)	E2[b]
1031.1	0.94(7)	Q	0.07(2)	E2

[a]The multi-polarities confirmed in the present work.
[b]The multi-polarities assigned in the present work.

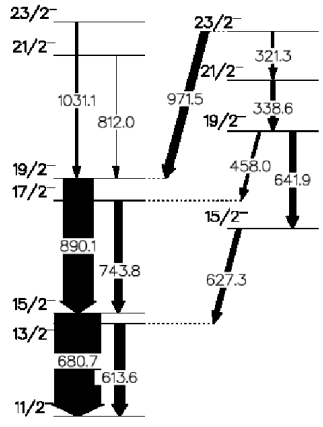

FIG. 1: Partial level scheme of ^{133}Ba.

A partial level scheme of ^{133}Ba is shown in Fig 1. In the previous study, the multi-polarity of the transitions 321.3 and 338.6 keV were tentatively assigned as M1 and for the 812.0 keV transition it was assigned as M1+E2 [2]. In the present work, the multi-polarity of these transitions were confirmed. Observing the obtained R_{DCO} and Δ of 458.0 and the 971.5 keV transitions, these transitions were assigned as M1+E2 and E2, respectively. Further analysis of the present work is in progress and detail results will be reported later.

Acknowledgments

This work was done in the Department of Physics and Astrophysics, University of Delhi, India. The authors would like to acknowledge the financial assistance at Delhi University from the University Grants Commission (UGC), India. The support provided by the staff of TIFR-BARC pelletron facility and the Nuclear Physics group at TIFR are also gratefully acknowledged.

References

[1] S. Frauendörf, Rev. Mod. Phys. **73**, 463 (2001).
[2] S. Juutinen *et al.*, Phys. Rev. C **51**, 4 (1995).
[3] A. Krmer-Flecken, T. Morek, R.M. Lieder, W. Gast, G. Hebbinghaus, H.M. Jger, W. Urban, Nucl. Instrum. Meth-ods Phys. Res., Sect. A **275** (1989) 333.
[4] R. Palit, H. C. Jain, P. K. Joshi, S. Nagaraj, B. V. T. Rao, S. N. Chintalapudi, and S. S. Ghugre, Pramana **54**, 347 (2000).
[5] R. Palit, AIP Conf. Proc. **1336** (2011) 573.
[6] D. C. Radford, Nucl. Instrum. Methods Phys. Res. A **361**, 297 (1995).