

## Polarization measurements and evidence for octupole correlations in $^{122}\text{Ba}$

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### Introduction

The nuclei that lie between the spherical ( $Z = 50$ ) and the well-deformed ( $Z = 58$ ) region are of considerable interest because of the competing shape driving tendencies of the orbitals occupied by the neutrons and the protons. The proton Fermi level lies near the low- $\Omega h_{11/2}$  orbitals, which favors the prolate nuclear shapes, whereas neutron Fermi level lies in the high to mid- $\Omega h_{11/2}$  orbitals, which favors the oblate nuclear shapes. Therefore, a variety of structures observed in this mass region are related to different shape driving forces because of the occupancy of the  $h_{11/2}$  orbitals for the valence protons and the neutrons. In this mass region, octupole collectivity has been observed in  $^{117}\text{Xe}$  [1], because both the proton and the neutron orbitals,  $h_{11/2}$  and  $d_{5/2}$  ( $\Delta l = 3$ ) are near the Fermi surface. The purpose of the present in-beam  $\gamma$ -spectroscopic investigation is to explore the structural features of the  $^{122}\text{Ba}$  nucleus. In the earlier investigations [2] for the level structure of  $^{122}\text{Ba}$  using in beam  $\gamma$ -ray spectroscopy, spin and parity for some of the observed rotational bands were not assigned or confirmed. In the present work, we have made an attempt to establish the unknown spin-parity of these bands using the linear polarization measurements. We have also confirmed some linking transitions between negative and positive parity bands.

### Experimental Details

High-spin states in the  $^{122}\text{Ba}$  nucleus were populated using the  $^{107}\text{Ag}(^{19}\text{F}, p3n)^{122}\text{Cs}$  fusion evaporation reaction at a beam energy of 93 MeV. The beam was provided by the 14UD Pelletron facility at TIFR (Mumbai, India). An isotopically enriched

$\sim 1\text{mg/cm}^2$ -thick  $^{107}\text{Ag}$  target on a  $10\text{-mg/cm}^2$  thick Au backing was used. The de-exciting  $\gamma$  rays were detected using the Indian National Gamma Array consisting of eight Clover detectors in conjunction with a 14-element NaI(Tl) multiplicity filter. The photo peak efficiency for the array was 1.6%. The detectors were coplanar and placed at  $60^\circ$ ,  $90^\circ$ ,  $120^\circ$ ,  $150^\circ$ ,  $210^\circ$ ,  $250^\circ$ ,  $285^\circ$ , and  $325^\circ$  with respect to the beam direction. A total of about 200 million triple or higher fold coincidence events were recorded in the experiment. Multipolarity of the de-exciting  $\gamma$  rays were deduced from the observed  $\gamma$ - $\gamma$  angular correlation measurements. DCO ratio measurement helps in unambiguous assignment of both spins and parities of nuclear states. The clover detector was used as a polarimeter to measure the polarization of the  $\gamma$ -rays.

### Results and Discussion

The partial level scheme of  $^{122}\text{Ba}$  resulting from the present work is shown in fig Fig.1. The transitions and their placement in the level scheme have been determined by  $\gamma$ -ray intensities using  $\gamma$ - $\gamma$  coincidences, reverse gating and sum energy relations. The width of arrows approximately equal to the intensities as obtained from the coincidence spectra of lowest transition  $196\text{ keV}(2^+ \rightarrow 0^+)$ . In this work, three tentative linking transitions  $504\text{keV}(7^- - 8^+)$ ,  $802\text{keV}(5^- - 6^+)$  and  $992\text{KeV}(8^+ - 6^-)$  have been confirmed. In the earlier work, the parity of band 2 and band 3 was tentatively assigned. The spin and parity of band 4 is also not confirmed. The multipolarity assignments have been performed with the DCO (Directional Correlations of the  $\gamma$  rays de-exciting Oriented

states) method. The  $R_{DCO}$  in the present work is defined as:

$$R_{DCO} = \frac{I_{\gamma_1}(\text{at } \theta \text{ gated by } \gamma_2 \text{ at } 90^\circ)}{I_{\gamma_1}(\text{at } 90^\circ \text{ gated by } \gamma_2 \text{ at } \theta)}$$

But angular correlation measurement is not sensitive to the electric or magnetic character of the radiation. The information on this can be obtained from the linear polarization measurements. The clover detector may be used as a Compton polarimeter in which each leaf acts both as a scatterer and as an analyzer counter to measure the scattering from the other two adjacent leaves. The linear polarization of the radiation can be determined through a difference between the number of Compton scattered gamma-rays in a parallel reaction plane ( $N_{\parallel}$ ) and a perpendicular plane ( $N_{\perp}$ ). The polarization asymmetry  $\Delta_{IPDCO}$  is defined as:

$$\Delta_{IPDCO} = \frac{aN_{\perp} - N_{\parallel}}{aN_{\perp} + N_{\parallel}}$$

Where  $a$  (plotted in figure 2) denotes the correction due to the asymmetry in response of the clover segments and is defined as

$$a = \frac{N_{\perp}(\text{unpolarized})}{N_{\parallel}(\text{unpolarized})}$$

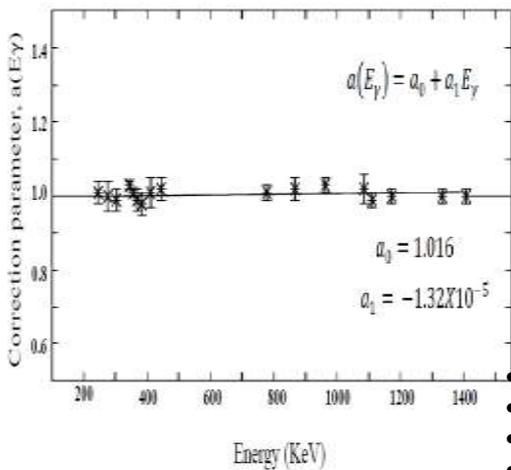


Fig. 2 Correction parameter  $a$  measured using  $^{152}\text{Eu}$  source.

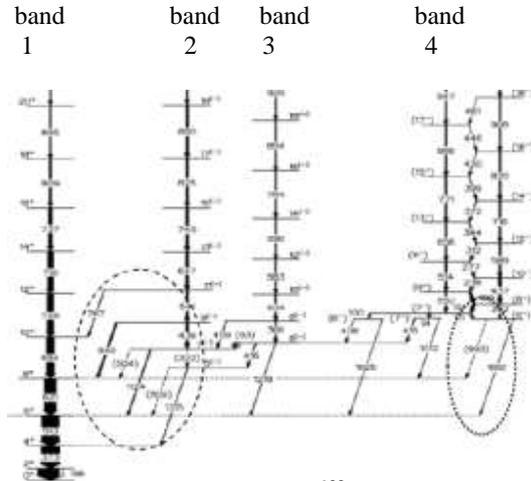


Fig.1 Partial level scheme of  $^{122}\text{Ba}$

Table 1. Measured Values of  $\Delta_{IPDCO}$  for the transitions of interest.

Energy (keV)	Transition	$\Delta_{IPDCO}$
787	$11^- - 10^+$	+0.06
940	$9^- - 8^+$	+0.06
992	$6^- - 8^+$	-0.004
1124	$7^- - 6^+$	+0.06

- Measured values of  $\Delta_{IPDCO}$  are tabulated in Table 1. On the basis of linear polarization measurements, the parity of band 2 is confirmed as negative. This negative band does not show any back bending and is similar to the negative bands observed in  $^{118}\text{Ba}$  and  $^{120}\text{Ba}$  [3,4]. On the basis of signature splitting and crossing frequency, it is interpreted as the favored signature of the proton configuration  $h_{11/2}[550]1/2^- \otimes g_{7/2}[422]3/2^+$  with a possible mixing of  $d_{5/2}[420]1/2^+$ . The strong E1 transitions 938 keV and 787 keV may be the possible evidence of octupole correlations [5].

**References**

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