Structure of the negative parity states in ^{131}Xe

S. Chakraborty,[1,*] S. Bhattacharyya,[1,2,†] R. Banik,[3] Soumik Bhattacharya,[1] G. Mukherjee,[1,2] S. Biswas,[4] S. Rajbanshi,[5] Shabir Dar,[1,2] S. Nandi,[1,2] Sajad Ali,[6] S. Chatterjee,[7] S. Das,[7] S. Das Gupta,[8] S. S. Ghugre,[7] A. Goswami,[9,2] A. Lemasson,[4] D. Mondal,[1] S. Mukhopadhyay,[1,2] H. Pai,[9] S. Pal,[1,2] D. Pandit,[1,2] R. Raut,[7] Prithwijita Ray,[9,2] M. Rejmund,[4] and S. Samanta[7]

[1] *Variable Energy Cyclotron Centre, Kolkata, India*
[2] *Homi Bhabha National Institute, Mumbai, India*
[3] *Institute of Engineering and Management, Kolkata, India*
[4] *Grand Accélérateur National d'Ions Lourds (GANIL), CAEN Cedex, France*
[5] *Department of Physics, Presidency University, Kolkata, India*
[6] *Department of Physics, Government General Degree College at Pedong, Kalimpong, India*
[7] *UGC-DAE Consortium for Scientific Research, Kolkata Centre, Kolkata, India*
[8] *Department of Physics, Victoria Institution (College), Kolkata, India*
[9] *Saha Institute of Nuclear Physics, Kolkata, India*

Introduction

Non-axiality in nuclear shapes has long been a subject of interest as it causes a variety of structural phenomena. Xe isotopes are well known for their triaxial shapes [1] and hence become a good laboratory to test several processes to generate higher angular momentum. Unique parity $\nu h_{11/2}$ orbital plays a crucial role on the structure of these nuclei. Systematically, two $I^{\pi} = 13/2^{-}$ states were reported in $^{119-127}$Xe, as shown in FIG. 1. Rotational band built on the yrast $13/2^{-}$ state is designated as the unfavoured signature partner of the $\nu h_{11/2}$ band. On the other hand, the band built on yrare $13/2^{-}$ state is described as the quasi-γ-band coupled to an odd-quasineutron in $h_{11/2}$ orbital. However, these interpretations fail to answer certain issues as discussed in Ref. [2]. Recently, different interpretations

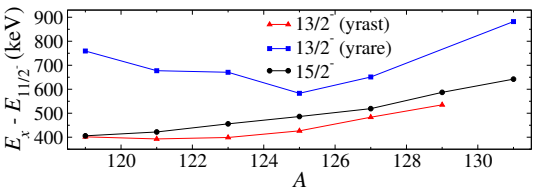

FIG. 1: Variation of the excitation energy, relative to $E_{11/2^-}$, of $15/2^{-}$ and $13/2^{-}$ (yrast and yrare) states in $^{119-131}$Xe, as a function of mass number.

are proposed for the negative parity bands in ^{127}Xe based on the electromagnetic properties of the $\Delta I = 1$ inter-band γ-transitions [3]. A detailed spectroscopic investigation on ^{131}Xe is reported recently, but, only the favoured signature partner of $\nu h_{11/2}$ band is observed [4]. Therefore, an attempt has been made in this work to search for the unfavoured signature partner of $\nu h_{11/2}$ band in ^{131}Xe.

Experimental Details

Excited states in ^{131}Xe were populated via ^{130}Te(^{4}He, 3nγ) fusion-evaporation reaction at 38 MeV, using K-130 cyclotron at VECC. The target consisted of isotopically enriched ^{130}Te, 2 mg/cm^2 thick, evaporated on a myler backing (600 μg/cm^2). Seven Compton suppressed Clover detectors of the Indian National Gamma Array [5], connected with a PIXIE based digital DAQ [6], were employed to detect and record the time stamped data in single and coincident modes.

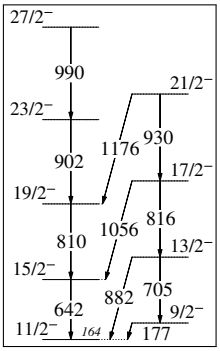

FIG. 2: The $\nu h_{11/2}$ band in ^{131}Xe.

Results

Partial negative parity level scheme of ^{131}Xe, as shown in FIG. 2, is developed in this work on the basis of $\gamma\gamma$-coincidence and inten-

*Electronic address: saikat.c@vecc.gov.in
†Electronic address: sarmi@vecc.gov.in

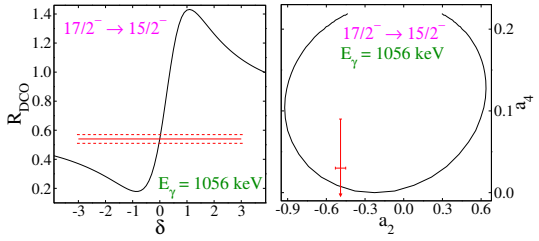

FIG. 3: (Left) Variation of the theoretical DCO ratio as a function of δ, and (Right) contour plot of the angular distribution coefficients, a_2 vs. a_4, for different δ. Experimental data point for the 1056 keV γ ray is marked in red.

sity relationships. The band above $I^\pi = 9/2^-$ state is established by placing three new γ rays, *viz.*, 882, 930 and 1176 keV in addition to the earlier reported 705, 816 and 1056 keV γ-transitions [4, 7]. The dipole (quadrupole) character of 882, 1056 and 1176 keV (705, 816 and 930 keV) γ-rays is confirmed from the present angular correlation measurement (R_{DCO}). To estimate the $E2/M1$ multipole mixing ratio ($\delta_{E2/M1}$) of the inter-band $\Delta I = 1$ γ-rays, the experimental R_{DCO} is compared with its theoretical values, estimated using the computer code ANGCOR. A representative plot of R_{DCO} versus δ for 1056 keV transition is shown in FIG. 3. It is evident from this figure that this γ ray has a very low $E2$ admixture ($\delta \approx 0$). Earlier reported angular distribution coefficients are also found in agreement with such low $\delta \approx -0.2$ value (FIG. 3) [7].

Discussions

Structure of the $\alpha = +1/2$ partner of $h_{11/2}$ band in odd-A nuclei has become a topic of investigation nowadays. In a recent study, the earlier reported signature partner of $\pi h_{11/2}$ band in ^{135}Pr has been reinterpreted in terms of wobbling excitation mostly, based on the large δ value of the connecting transitions [8].

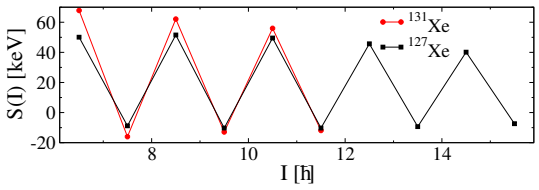

FIG. 4: Energy staggering [S(I)] between the $\alpha = \pm 1/2$ partners of $\nu h_{11/2}$ band in ^{127,131}Xe.

Later, the wobbling motion is also confirmed for the so-called unfavoured signature partner of $\pi h_{11/2}$ ($\nu h_{11/2}$) band in ^{133}La (^{127}Xe, ^{105}Pd) [3, 9, 10]. Therefore, proper identification of the unfavoured signature partner of $h_{11/2}$ band is important to understand the structure of this band.

Systematically, two bands were reported above yrast and yrare $13/2^-$ states in $^{119-127}$Xe. However, no such bands is found in the latest studies on ^{131}Xe [4, 11]. The spin-parity assignment, and the decay pattern of the newly established band above $I^\pi = 9/2^-$ state make it a suitable candidate for the unfavoured signature partner of $\nu h_{11/2}$ band. Low $E2$ admixture in the $\Delta I = 1$ inter-band transitions provide further support to this interpretation. The energy staggering [S(I)] between $\alpha = \pm 1/2$ partners of $\nu h_{11/2}$ band in ^{131}Xe is found to be similar to that reported in ^{127}Xe (FIG. 4).

Summary

Low-lying negative parity states in ^{131}Xe were studied following an α-induced reaction at VECC, Kolkata. The unfavoured signature partner of $\nu h_{11/2}$ band has been identified with firm spin-parity assignment. The S(I) value is found to be large and comparable in magnitude with that reported in ^{127}Xe. The detailed results along with the theoretical calculations under the framework of particle-rotor model will be presented.

Acknowledgement

We are thankful to the VECC cyclotron staff for providing excellent α-beam. Effort of INGA collaboration, partially funded by DST, GoI, is gratefully acknowledged. Financial support received from CEFIPRA is duly acknowledged.

References

[1] A. Gelberg *et al.*, NPA **557**, 439c (1993).
[2] C.-B. Moon *et al.*, PRC **76**, 067301 (2007).
[3] S. Chakrabrty *et al.*, PLB **811**, 135854 (2020).
[4] R. Banik *et al.*, PRC **101**, 044306 (2020).
[5] S. Bhattacharya *et al.*, Proc. DAE Symp. **63**, 1156 (2018).
[6] S. Das *et al.*, NIM A **893**, 138 (2018).
[7] T. Lönnroth *et al.*, PS **27**, 228 (1983).
[8] J. T. Matta *et al.*, PRL **114**, 082501 (2015).
[9] J. Timár *et al.*, PRL **122**, 062501 (2019).
[10] S. Biswas *et al.*, EPJA **55**, 159 (2019).
[11] L. Kaya *et al.*, PRC **98**, 014309 (2018).