Revealing multiple band structures in ^{131}Xe from α-induced reactions

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

[1]*Variable Energy Cyclotron Centre, 1/AF Bidhannagar, Kolkata 700064, India*
[2]*Homi Bhabha National Institute, Training School Complex, Anushaktinagar, Mumbai 400094, India*
[3]*GANIL, CEA/DRF-CNRS/IN2P3, BP 55027, F-14076 Caen Cedex 5, France*
[4]*Department of Physics, Presidency University, Kolkata 700073, India*
[5]*Saha Institute of Nuclear Physics, Kolkata 700064, India*
[6]*UGC-DAE CSR, Kolkata Centre, Kolkata 700098, India*
[7]*Victoria Institution (College), Kolkata 700009, India*

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The excited states in the transitional nucleus ^{131}Xe have been populated by using α-induced fusion-evaporation reaction and the de-exciting γ rays were detected with the Compton suppressed clover detector setup of the Indian National Gamma Array coupled to digital data acquisition system. The existing level structure of ^{131}Xe has been significantly extended with the observation and placement of 72 new γ-ray transitions. The use of light-ion (α) beam helped to identify several new band structures in ^{131}Xe with different quasiparticle (qp) configurations. The multipolarities of the observed γ rays have been determined on the basis of the directional correlation from oriented states ratio and polarization asymmetry measurements. The yrast negative-parity band has been confirmed up to $35/2^-$ spin and the highly nonyrast signature partner of this band has been identified for the first time. The positive-parity band, based on the $3/2^+$ ground state, has been extended up to $23/2^+$ with the observation of a signature inversion, which signifies a pair of particle alignment around the spin of 15/2 $\hbar$. A dipole band, consisting of $M1$ transitions has been identified and assigned a 5-qp configuration. A new band structure built on a 3-qp $23/2^+$ state has been observed with a large signature splitting. A comparison in the isotopic and isotonic chains reveals the transitional nature of the $N = 77$ nuclei. Total Routhian surface calculations have been performed to understand the structure of ^{131}Xe associated with different configurations.

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I. INTRODUCTION

The transitional nuclei in the $A = 130$ region, above the $Z = 50$ proton shell closure and below the $N = 82$ neutron shell closure, provide a rich variety of single-particle and collective structures and their coexistence [1–3]. The vibrational bands, signifying mostly the spherical structures, are more prominent in nuclei near the $N = 82$ shell closure, while the rotational bands, signifying the deformed structures, appear with several numbers of neutron holes below $N = 82$. A similar situation arises for nuclei with proton number close to or away from the $Z = 50$ shell closure. The nuclei with a few numbers of neutron holes and proton particles with respect to the $N = 82$ and $Z = 50$ shell closures are the transitional ones in this region. The structure of these transitional nuclei depends largely on the shape driving effect of the orbitals which are occupied by the odd nucleon. Most of the even-even nuclei in this transitional region are known to depict softness with respect to γ deformation [4]. It is, therefore, possible that the addition of an extra nucleon in different orbitals near the Fermi surface drives the structure of an odd-A nucleus in different shapes depending on the shape driving effect of the involved orbital. In this context, it is very interesting to study the different band structures of odd-A nuclei in the transitional region which will provide important information on the shape driving effect of different orbitals. Such an effect of some of the neutron orbitals has been reported in the nuclei in the $A \approx 130$ region from the observation of different rotational band structures [5,6]. Moreover, both proton and neutron Fermi levels of the nuclei in this mass region lie within the same major shell, that is, the Z, $N = 50$–82 shell. Hence protons (as particles) and neutrons (as holes) can occupy different (e.g., low-Ω and high-Ω) components of the same high-j, $h_{11/2}$ orbital. Therefore, different polarizing effects of these components, as well as different phenomena arising due to particle-hole combination, may be manifested in the level structure of the same nucleus. This can be investigated by studying various quasiparticle (qp) excitations in nuclei of this region. The involvement of the unique-parity, high-j $h_{11/2}$ orbital plays a key role in generating high-spin states

*Corresponding author: sarmi@vecc.gov.in
†Deceased.

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