High spin structure in ^{131}Ba

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Introduction

In mass region A ~ 130, the proton Fermi surface lies near the bottom of $h_{11/2}$ shell, while the neutron Fermi surface lies in the upper $h_{11/2}$ midshell. As a consequence, at low rotational frequency, the nuclear shape is strongly influenced by the valence quasiparticles. At higher frequencies, the alignment of quasiparticles pairs introduces an additional driving force that can significantly change the nuclear shape. In addition, strong γ-driving forces are expected for quasiparticles in high- j orbitals which have deep energy minima at specific value of γ, dependent upon where the Fermi surface lies within the high-j shell. In this mass region, lower mid-shell $h_{11/2}$ protons (derived from low-Ω orbitals) favour prolate nuclear shapes (γ = 0°) while upper-midshell $h_{11/2}$ neutrons (derived from high-Ω orbitals) favours shape close to oblate shape (γ = -60°). The rotational alignment of upper-midshell $h_{11/2}$ neutrons can thus induce a shape change for γ-soft cores driving them toward a collectively-rotating oblate shape. The neutron number N=75 lies in a γ-soft region intermediate between prolate (N≤74) and triaxial (N≥76) shapes. The active proton orbitals for these nuclei are the unique parity intruder $h_{11/2}$, $d_{5/2}$, $g_{7/2}$, and the extruder $g_{9/2}$. Moreover, because of the different shape driving effect for proton and neutrons, many of the nuclei in this region are triaxial which leads to a band structure with novel angular momentum coupling schemes like chiral bands and magnetic rotational bands. Strongly coupled ΔI=1 rotational bands built on multiquasiparticle states with such as oblate shape, have recently been established in odd-Z ^{131}La, ^{133}Pr nuclei. Collectively rotating oblate bands are also found in odd-N ^{135}Ce nucleus.

Experimental Set-up

In the present work, high spin states in ^{131}Ba have been studied through the ^{122}Sn (^{13}C, 4n) ^{131}Ba heavy ion fusion evaporation reaction with a beam energy of 65 MeV. The experiment was carried out at the 14–UD pelletron accelerator at IUAC, New Delhi, India, which delivered ^{13}C beam on a ~ 1.0mg/cm^2 thick ^{122}Sn target with Au (6.7mg/cm^2) backing . The γ-decay following the reaction was studied using an array consisting of Compton suppressed clover detectors of INGA (Indian National Gamma Array) placed at angle of 32° , 57°, 90°, 123°, 148° with respect to the beam direction. The data were collected when two or more clovers were fired.

Experimental Results

Data have been analyzed using software CANDLE, INGASORT and RADWARE. Symmetric and Asymmetric matrices have been constructed using 2-fold as well as 3-fold data. Cube has also been made for 3-fold data. In extension to earlier work done by R. Ma et al. [**1**], we have placed some of the transitions in high spin states and also we have assigned spin and parity [**2]** for Band No. 3 (Fig.1.) for the first time.

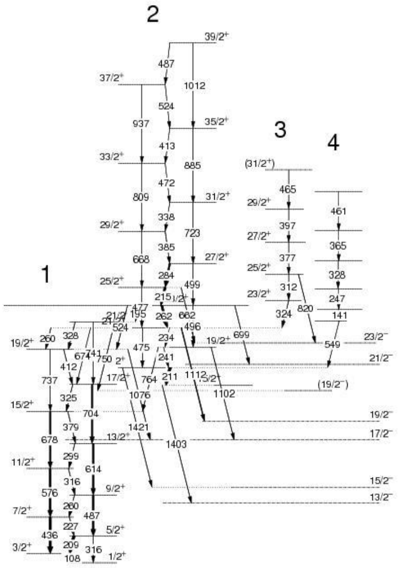

Fig. 1 partial level scheme of ^{131}Ba

Experimental alignments $i_x = I_x - I_{x,\ ref}$ for three bands are presented in Fig.2 as a function of rotational frequency. Here I_x is estimated as $I_x = [(I+1/2)^2-K^2]^{1/2}$. $I_{x,\ ref}$ is based on a frequency-dependent variable moment of inertia reference $\Im_{ref} = \Im_0 + \Im_1\ \omega^2$, where Harris parameters, $\Im_0 = 11.9\ \hbar^2\ MeV^{-1}$, $\Im_1 = 21.1\hbar^4\ MeV^{-3}$ are used [1].

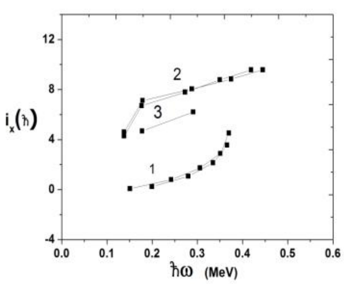

Fig. 2 Experimental alignments i_x for the bands (1-3) in ^{131} Ba

Band structure, similar to band 3, has been observed in ^{133}Ce [3]. Due to strong $\Delta I=1$ transitions and lack of signature splitting, this band has been predicted to be built on prolate three quasiparticles configuration $\upsilon h_{11/2} \otimes \pi h_{11/2} \otimes \pi g_{7/2}$. The favored signature of the $h_{11/2}$ proton orbital is coupled to the unfavoured signature of the $g_{7/2}$ proton orbital. These protons are then coupled to both signature of $h_{11/2}$ neutron orbital results a rotational band with no signature splitting. From the alignment plot for this band, one can see the rotational frequency near the band head is ~0.17 MeV. So, the TRS calculation at $\hbar\omega$ = 0.16 MeV, shown in Fig. 3, will provide the information about the shape for this configuration near the band head. Two close lying minima can be seen in this Fig. 3; both indicate triaxial deformation. One has $\beta_2 = 0.19$ and $\gamma = -89°$ and the other one has $\beta_2 = 0.18$ and $\gamma = -28°$. It can be seen from Fig. 4 that at higher frequencies ($\hbar\omega$ = 0.36), the minimum has been shifted to an oblate shape with $\beta_2 = 0.15$ and $\gamma = -60°$.

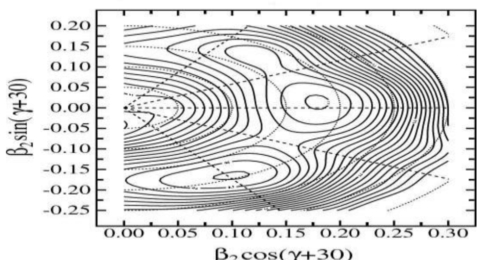

Fig. 3 TRS plot for the band 3 in ^{131}Ba at a rotational frequency of $\hbar\omega$ = 0.16 MeV

Therefore, the TRS calculations indicate that the structure for the $\upsilon h_{11/2} \otimes \pi h_{11/2} \otimes \pi g_{7/2}$ configuration in ^{131}Ba changes from triaxial to an axial shape with oblate deformation after the band crossing in this 3qp band. A band crossing is predicted in the cranked shell model [CSM] calculations for this band at $\hbar\omega$ ~ 0.3 MeV and has been observed in band 2 which has the same configuration but different signature.

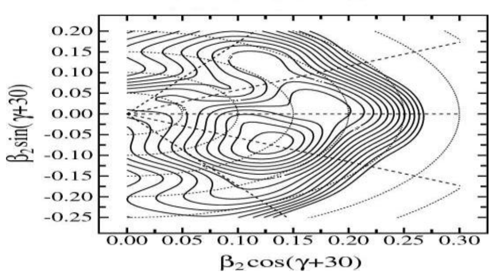

Fig. 4 Same as Fig. 3 but at $\hbar\omega$ = 0.36 MeV

References

[1] R.Ma et al., Phys. Rev. C41(1990) 2.
[2] Navneet Kaur et al., Proc DAE symposium Nucl. Phys. 55A (2010)10.
[3] R.Ma et al., Phys. Rev. C36 (1987) 6.