Search for signature partner band in ^{133}La

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Introduction

The wobbling modes of an triaxial nucleus was first described by the Bohr and Mottelson [1]. This mode represents the quantized oscillations of the principal axes of an asymmetric top relative to the space-fixed angular vector. Later, Frauendorf and Dnau seperate the wobbling motion based on the wobbling energy (E_{wobb}) as a function of increasing spin [2]. The wobbling energy increases with increasing spin called longitudinal wobbling, whereas the wobbling energy decreases as a function of spin produced transverse wobbling motion. The first experimental evidence of wobbling motion in the nucleus was observed in ^{163}Lu isotope [3]. Later, different types of wobbling motion were exhibited in many nuclei such as ^{135}Pr[4, 5], ^{127}Xe [6], and ^{133}La[7]. A one-phonon wobbling band in the ^{133}La nucleus was previously confirmed based on the ΔI = 1, E2 nature of the linking transitions and increase in wobbling frequency as function of spin. However, locating the position of the signature partner band in ^{133}La is still necessary to complete the picture of the wobbling mode in ^{133}La. In the present work, we have identified and place two new $\Delta I = 2$ bands in the level structure. The spin and parity were confirmed through R_{DCO} and linear polarization measurements. Furthermore, the mixing ratios of the interconnecting transitions and the B(E2) ratios suggest that band C is possible signature partner band in the ^{133}La nucleus.

Experimental Details

In light of this, we conducted an experiment using the fusion-evaporation reaction ^{133}Cs(^{4}He, 4n)^{133}La to search for the signature partner band in the low-spin regime of ^{133}La, aiming to complete the picture of the wobbling mode in this nucleus. A 1.4 mg/cm^2 isotopically enriched ^{133}Cs target was evaporated onto a 1 mg/cm^2 Mylar backing. A 52-MeV α beam, provided by the K-130 cyclotron at VECC (Kolkata), was used, and the de-excited γ-rays were detected using the INGA setup, which comprised eight Compton-suppressed HPGe clover detectors positioned at three different angles (40°, 90°, and 125°) along with one LEPS (Low Energy Photon Spectrometer) detector. The list-mode data acquired was processed using the IUCPIX package [8], developed at UGC-DAE CSR, Kolkata Centre, and analyzed using RADWARE. The γ-γ-γ cube contained approximately 6.7 $\times$ 10^7 events, which were analyzed using the RADWARE package to obtain coincidences between

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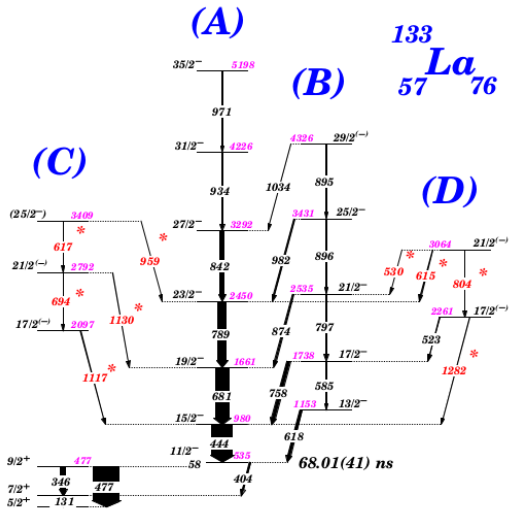

FIG. 1: Partial level scheme of ^{133}La based on the present work and the previous study [7]. The newly observed transitions are marked by asterisks and shown in red color. All energies are in keV.

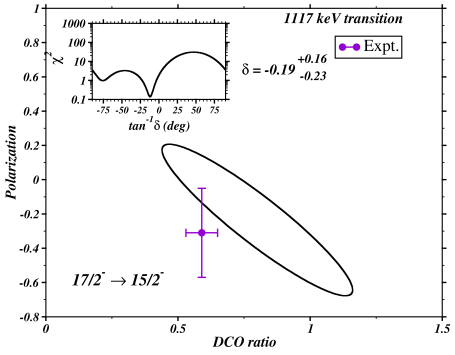

FIG. 2: The variation of R_{DCO} as a function of the polarization at different mixing ratio (δ) for 1117 keV transition in ^{133}La in which the inset shows the minimum of the χ^2 versus $\tan^{-1}\delta$ plot giving mixing ratio δ=-0.19$^{+0.16}_{-0.23}$.

different γ-rays and construct the level scheme.

Results and Discussion

In this present work, two new negative parity bands with ΔI=2 (labeled as C and D), consisting of nine newly identified transitions, have been added to the level scheme. Band C includes five newly observed γ-ray transitions with energies of 1117, 694, 617, 1130, and 959 keV, and extends up to $(25/2^-)$ with an excitation energy of 3.409 MeV. The representative spectra confirming the transitions of these bands from the 445 keV and 681 keV transition gates are displayed in Fig. 1. Additionally, a new negative-parity band D, has been observed up to $(21/2^-)$ state at an excitation energy of 3.064 MeV, comprising with four new γ-ray transitions with energies of 1282, 804, 615, and 530 keV.

The spin and parity assignments of the γ-ray transitions were determined using the directional correlation of oriented states (R_{DCO}) ratio and linear polarization measurements. Through this analysis, the mixing ratios for the 758, 874, and 982 keV transitions were found to be -2.61$^{+1.12}_{-1.32}$, -2.05$^{+1.44}_{-1.43}$, and -2.05$^{+1.63}_{-1.68}$, respectively, for σ/j = 0.37. These results confirm the presence of a single-phonon wobbling band in this nucleus.

Furthermore, the R_{DCO} and linear polarization values for the 1117 keV transition were determined to be 0.59 (0.06) and -0.31 (0.26), respectively. The mixing ratio for this transition was found to be -0.19$^{+0.16}_{-0.23}$, displayed in Fig 2, indicating that the dominating M1 nature, confirming it as the signature partner of the wobbling band.

Further analysis along with the results will be presented during the conference.

Acknowledgement

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