Spectroscopy of ^{133}La and search for wobbling phenomenon

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Introduction

In nuclear spectroscopy, most often we come across nuclei that are either spherical or axially symmetric. However, certain combinations of single-particle orbitals near the Fermi surface can lead to a triaxial shape [1]. The spectra of these three categories of nuclei have significant differences and this property is used to determine the shapes of nuclei experimentally. The unique signatures of a triaxial nuclei are wobbling and chirality. The wobbling band is characterized by ΔI = 1 inter-band E2 transitions and ΔI = 2 intra-band E2 transitions and a 1/I decrease of the B(E2$_{out}$)/B(E2$_{in}$) values. The wobbling motion has been experimentally established at very high spins in the triaxial strongly deformed nuclei with $(\varepsilon_2,\gamma) \sim (0.40, 20^o)$ around Z = 72, N = 94, namely in the isotopes ^{163,165,167}Lu and ^{167}Ta. In these isotopes, the wobbling frequency has been seen to be decreasing with increasing spin which is a case of transverse wobbling [2]. For the first time, at low spin transverse wobbling has been established in ^{135}Pr [3]. The longitudinal wobbling mode, characterized by an increase in wobbling frequency with spin, has been reported only in ^{112}Ru signifying a stable triaxial ground state [4]. Systematic study of nuclei near ^{135}Pr will provide new insight on wobbling phenomenon. Therefore, the spectroscopy of ^{131}Cs and ^{133}La has been carried out using INGA. Here we will discuss the result of ^{133}La.

Experimental Details

High-spin states of ^{133}La were populated in the fusion-evaporation reaction ^{126}Te(^{11}B, 4n). ^{11}B beam at 52 MeV energy, provided by the TIFR-BARC Pelletron facility was used to bombard a ^{126}Te target of thickness 1.1 mg/cm^2 backed with 9.9 mg/cm^2 of ^{197}Au. The gamma-rays emitted were detected using the INGA spectrometer. The spectrometer consisted of 21 Compton suppressed HPGe clover detectors. Two and higher fold clover coincidence events were recorded in a fast digital data acquisition system (DDAQ) based on Pixie-16 modules of XIA LLC [5].

The data sorting routine “MultipARameter time-stamp-based COincidence Search program (MARCOS) ”, developed at TIFR was used to sort the time-stamped data to generate one-dimensional histograms, E$_\gamma$ -E$_\gamma$ matrices, and E$_\gamma$-E$_\gamma$-E$_\gamma$ cubes. The time window for the prompt γ-γ coincidence was set to 500 ns. A set of 3×10^8 three- and higher-fold events were available for the subsequent analysis. The RADWARE software package was used for the analysis of the matrices and cubes. The spin and parities of the excited states in ^{133}La were determined from the DCO and linear polarization measurements of the de-exciting gamma-ray transitions.

Results and Summary

The spectrum obtained by using a sum of double gates on energies 445, 681 and 789 keV in the zero-phonon yrast band (n$_\omega$ = 0) has

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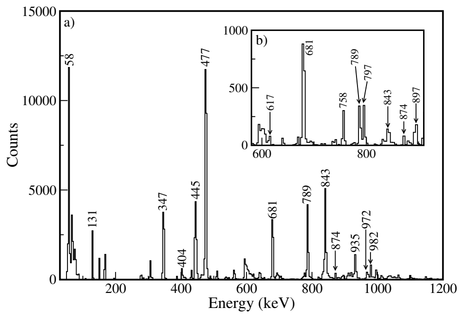

FIG. 1: (a) Gamma-ray spectrum using a sum of double gates on energies 445, 681 and 789 keV in the zero-phonon yrast band. (b)Gamma-ray spectrum using a sum of gates on 585, 797, 897 keV transitions in the one-phonon band vs 617, 758, and 874 keV inter-connecting transitions.

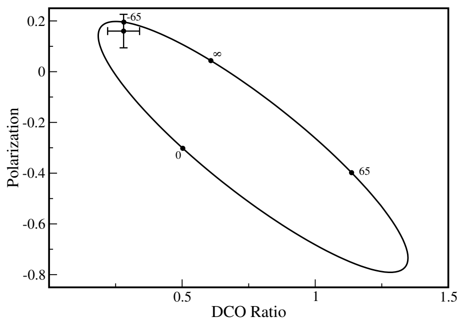

FIG. 2: The theoretical values of DCO and polarization of 758 keV transition have been plotted for different mixing ratios along with the experimentally obtained values for the same transition.

been shown in Fig. 1(a). Fig. 1(b) shows the spectrum obtained by using a sum of gates on 585, 797, 897 keV transitions in the one-phonon ($n_\omega = 1$) band *vs.* 617, 758, and 874 keV inter-connecting transitions between the $n_\omega = 0$ and $n_\omega = 1$ wobbling bands. In order to establish the one-phonon ($n_\omega = 1$) wobbling band, the theoretical plots of the variation of DCO and linear polarization with mixing ratio for all the inter-band transitions were compared with the experimental values (see Fig. 2 for the 758 keV transition, for example). The calculated $B(E2_{out})/B(E2_{in})$ values for the band decreases with increasing spin establishing its wobbling nature. Furthermore, a longitudinal wobbling behavior is suggested for the band as the wobbling frequency has been observed to increase with spin. Detailed theoretical calculations are in progress.

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