High-K states and band structures in Yb isotopes

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Introduction

Nuclei in the Yb region ($A \approx 170$) constitute some of the best examples of normal-deformed axially symmetric rotors known. Additionally, the valence neutron orbitals from the $i_{13/2}$ subshell are characterized by large Ω values. This allows for an understanding of the competition between rotational and quasiparticle degrees of freedom, and the Coriolis coupling between these excitation modes. The presence of high-j orbitals in this region allows for the realization of multiple band structures in addition to the ground state rotational band.

High-j orbitals can have relatively high components of angular momentum projection (Ω) along the symmetry axis. The presence of these orbitals originating from high-j proton and neutron sub-shells in this region suggest that high-K ($K = \sum \Omega_i$) states, some of which may be isomeric, are expected in Yb isotopes. K isomers have been observed in some Yb isotopes, however a few others have not yet been studied up to high spin using thick targets [1–5].

The aim of the experiment was to study high-K states, rotational and vibrational band structures and the evolution of collectivity along the Yb isotopic chain. Identification of the high-K states and associated bands and lifetime measurements for possible longer-lived isomers ($T_{1/2} > 100$ ns) is one of the objectives. The band structures built on the high-K states and the branching ratios for the decay of the levels in these rotational bands would also allow for configuration assignments.

Experiment and Analysis

In the present work, excited states have been populated in Yb isotopes using alpha-induced reactions on a thick, natural erbium target. An alpha beam at 45 MeV was delivered by the K-130 cyclotron at the Variable Energy Cyclotron Centre (VECC), Kolkata. The INGA (Indian National Gamma Array) facility at VECC, consisting of 8 clover HPGe and 2 LEPS detectors were used to record two- and higher-fold gamma ray coincidence events. The PIXIE-16 digitizer-based data acquisition system along with the associated software package IUCPIX [6] of UGC-DAE CSR, Kolkata, was used to sort the data into different two- and three-dimensional histograms.

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Results and Discussion

Preliminary analysis of the data has allowed verification of the already established rotational bands and side bands in the Yb isotopes. Excited states in the strong rotational bands in the even Yb isotopes are observed up to spin 20$\hbar$. The presence of known transitions from the decay of K isomers in ^{168,170,172}Yb was also evident. The partial level schemes of ^{168,170,172}Yb showing known K isomers [7–9] and their feeding and decaying transitions to the ground-state rotational bands have been shown in Fig. 1.

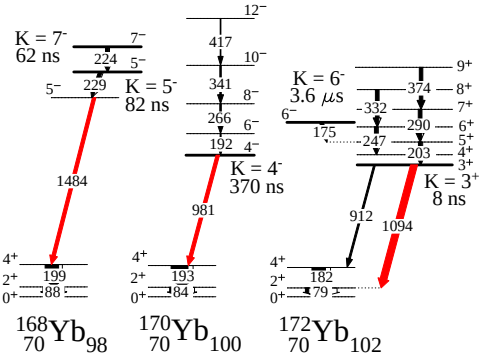

FIG. 1: Partial level schemes of ^{168,170,172}Yb with known K isomers and their halflives.

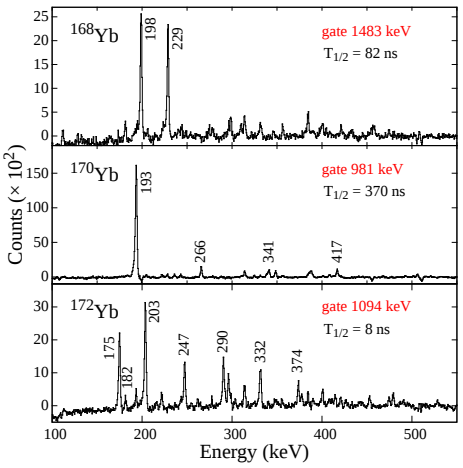

FIG. 2: Spectra from the decay of K isomers in ^{168,170,172}Yb.

The spectra from gates on their respective decaying transitons in a two-dimensional energy histogram are also shown in Fig. 2.

Further analysis is in progress to determine the presence of other high-K states and their lifetimes in the 100 ns - few μs time range. It is also proposed to explore the evolution of collectivity in Yb isotopes at high spin with increasing neutron number.

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