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Band structure on a two-quasiparticle K-isomer in ^{156}Gd

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Introduction

The evolution in nuclear structure is evident across the gadolinium isotopes, through transition from near closed-shell behavior in ^{146}Gd towards deformation in the heavier members of the chain. The appearance of 2^+ state in ^{156}Gd at low excitation of 89 keV is characteristic of well-deformed rare-earth nuclei above $N = 90$.

Many K -isomers have been reported across the nuclear chart, most prominently in the regions around $A \approx 130$ and $A \approx 180$, and, more recently, near $A \approx 250$ [1, 2]. In contrast, K -isomers are relatively rare in the rare-earth region around $A \approx 150$, which makes their identification particularly significant.

A 7^- state at an excitation energy of 2138 keV is firmly established in $N = 92$ ^{156}Gd with measured half-life $1.3 \mu\text{s}$ [3]. The hindrance factors for the $E1$ transitions deduced from the observed lifetimes support the K -isomer interpretation for this level. This state decays to the ground state through the $K^\pi = 4^+$ band. In the neighboring $N =$

90 ^{154}Gd , a 7^- isomer of half life 68 ns has been reported [4] at the same excitation energy of 2138 keV which, in contrary, decays directly to the ground state band of this nucleus. This isomer was explained in terms of a two-quasineutron configuration $\frac{3}{2}^+[651] \uparrow + \frac{11}{2}^- [505] \uparrow$, based on a $\frac{11}{2}^-$ isomer, known in odd- N isotope ^{155}Gd at 122 keV and interpreted as $\nu \frac{11}{2}^- [505] \uparrow$ Nilsson states [5].

By combining available Nilsson states lying close to the Fermi level at $N = 92$ for a deformation $\epsilon \approx 0.3$, two possible Nilsson configurations $\nu[\frac{3}{2}^+[651] \uparrow + \frac{11}{2}^- [505] \uparrow]$ and $\nu[\frac{3}{2}^+[402] \uparrow + \frac{11}{2}^- [505] \uparrow]$ were suggested which could form the 7^- state in ^{156}Gd [3]. It is still not known whether either one of these configurations, or a mixture of them, is involved in the formation of this K -isomeric state. In this context, band structure developed on the 7^- isomer as well as precise lifetime measurement of this level is of particular interest.

In this work, the $(\alpha, 2n)$ reaction has been used to establish a new band structure on the 7^- isomeric state and to explore the behaviour of this $K^\pi = 7^-$ band.

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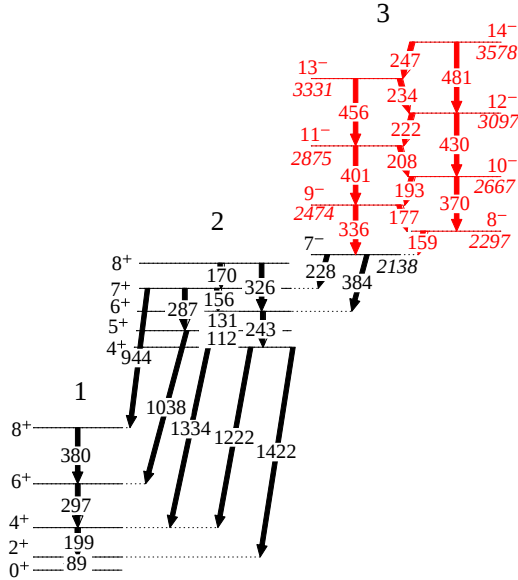


FIG. 1: Partial level structure of ^{156}Gd , established in this work, showing the ground-state band (1), $K^\pi = 4^+$ band (2) and the newly found band (3). New γ rays, levels and spin-parities are shown in red.

Experimental Details

^{156}Gd was populated using the $^{154}\text{Sm}(\alpha, 2n)^{156}\text{Gd}$ reaction at an incident alpha energy of 27 MeV delivered by the K-130 cyclotron at VECC, Kolkata. The target consisted of a 6.5 mg/cm² thick ^{154}Sm layer backed with 0.5 mg/cm² Mylar. The de-exciting γ rays were detected using the Indian National Gamma Array (INGA) comprising eleven clover HPGe detectors and one LEPS detector. The data were recorded in list mode using PIXIE-16 digitizers [6] and data were sorted using the program IUCPIX [6] and BiNDAS [7].

Analysis, Results & Discussions

$\gamma - \gamma$ and triple γ coincidence analysis was performed using RADWARE [8] for developing the band structure shown in Fig. 1. The projections from triple γ cube indicating the newly observed γ transitions shown in Fig. 2.

Directional Correlation from Oriented states

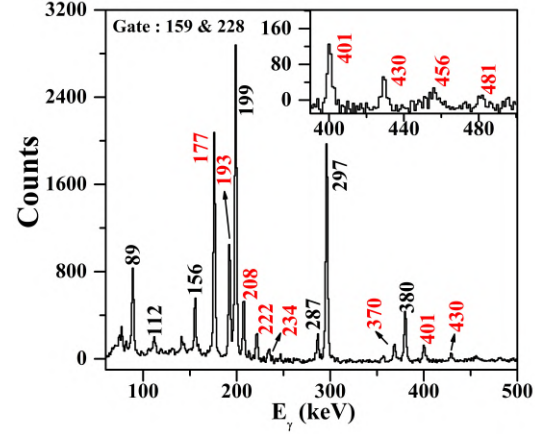


FIG. 2: The $\gamma - \gamma - \gamma$ coincidence spectra from clover-clover coincidence. New observed transitions are marked in red. The inset shows zoomed-in spectra beyond 390 keV.

(DCO) and Integrated Polarization Directional Correlation (IPDCO) analysis was done to confirm spin-parity. Routhian and alignment was studied in comparison to the two quasiparticle $K^\pi = 7^-$ band in ^{154}Gd to understand the configuration.

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