Negative parity band in ^{152}Gd

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Introduction

The light rare-earth nuclei around N ≈ 88 and Z ≈ 64 are transitional in nature, where the addition of a couple of neutrons changes the nuclear structure from a vibrational to a rotational character. The presence of negative parity bands near to the ground state of even-even nuclei shows mixing of dipole, quadrupole and octupole modes of excitation. Further, the presence of excited 0^+ bands shows the shape co-existing phenomeneon in these nuclie. The Gd nuclei being in the middle of the region, are interesting to study, as they can give a straightforward interpretation in terms of interplay between these different degrees of freedom.

High spin structure of ^{152}Gd nucleus was earlier studied by [1, 2] using heavy ion fusion reaction. The results of these studies dont coincide for the band build on 2536 keV band head and connected via 790, 590, and 462 keV transitions to the ground state band. In this work, the spectroscopic results for the same band with aditional information of polarization measurement of connecting gamma rays alongwith the directional correlation and the coincidence results are presented.

Experiment

High spin states in ^{152}Gd nucleus were populated via ^{138}Ba(^{18}O, 4nγ) fusion-evaporation reaction at a beam energy of ≈ 73 MeV, delivered from the 15UD pelletron accelerator facility at Inter-University Accelerator Centre (IUAC), New Delhi. Fifteen Compton-suppressed clover HPGe detectors were employed in the Indian National Gamma Array (INGA) to detect the de-exciting γ-rays [3]. About 5×10^8 two or higher fold γ-events were recorded via analog data acquisition system CANDLE [4]. The raw data were sorted into different 4k×4k symmetric and asymmetric matrices using INGASORT [5]. Offline

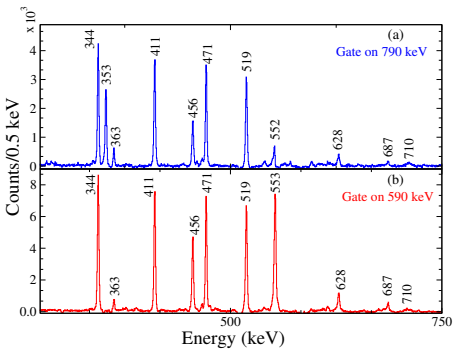

FIG. 1: Background subtracted coincidence spectra obtained by putting a gate on (a)790 keV and (b) 590 keV transitions.

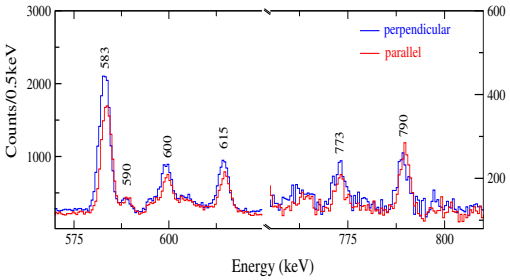

FIG. 2: The parallel and perpendicular components of selected gamma-rays in 90° detectors ; in 519 keV energy gated spectrum of ^{152}Gd.

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data analysis was carried out using the RADWARE [6], and CANDLE [4] analysis packages.

The level scheme is developed using the intensity patterns and co-incidence correlarions betwen the observed γ-transitions. The multipolarities and the electromagnetic nature of the observed γ-transitions have been determined from the results of angular correlation (R_{DCO}) and The Integrated Polarization Directional Correlation from Oriented nuclei (IPDCO) method respectively.

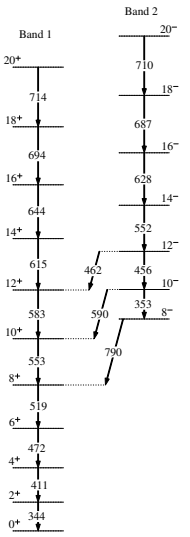

FIG. 3: Partial level scheme of ^{152}Gd observed in the present experiment.

Result and Discussion

Ref. [1] has shown 552 keV in the band 2 (see FIG.3) while it has not been observed in the ref. [2]. FIG. 1 shows the background subtracted coincidence spectra obtained in the present work by putting a gate on connecting transitions between two bands (band 1 and band 2 in FIG.3) (a) 790 keV and (b) 590 keV transitions. These spectra shows the presence of 552 keV transitions in the band 2, though nearby 553 keV transition is also present in the main ground state band, band 1. The findinds of the present work are consistent with the ref.[1].

Further, to assign spin and parity to the levels of band 2, R_{DCO} and (IPDCO) measurement have been carried out. FIG.2 shows the projected spectra for the parallel and perpendicular coincident events recorded in the detectors at 90^o with respect to the beam axis. These parallel and perpendicular coincidence events are different for a gamma ray if it is electric or magnectic in nature. It can be seen from the FIG 2 that 590 and 790 keV transtions have different electromagnetic nature than the other observed e.g. 583, 600, and 615 keV transitions. The results of angular correlation (R_{DCO}) and Polarization measurement are tabulated in the Table-I. The procedure for these methods is given in ref.[7]. Based on the results presented in Table-I, the spin and parity of the band head of band 2 at 2536 keV is assigned as 8^-.

TABLE I: The details of observed γ-ray transitions in band 2 and connecting transitions between band 2 and band 1.

$E_\gamma(keV)$	$E_i(keV)$	$R_{DCO}{}^a$	$\Delta_{Pol}{}^a$	$J_i^\pi \rightarrow J_f^\pi$
790.1	2536	0.85(3)	-0.09(4)	$8^- \rightarrow 8^+$
589.8	2889	0.96(2)	-0.10(4)	$10^- \rightarrow 10^+$
461.9	3345	0.97(8)	-	$12^- \rightarrow 12^+$
353.0	2889	1.24(5)	0.11(4)	$10^- \rightarrow 8^-$
455.7	3345	0.75(3)	0.12(3)	$12^- \rightarrow 10^-$

[a]Gate on 519 keV quadrupole transition

In conclusion, high spin states of ^{152}Gd are populated via fusion evoporation reaction. High spin negative parity band is studied in this work. Gamma-gamma coincidence relations and intensity patterns shows the presence of 552 keV transition in band 2. Angular correlation and polarization measurements are used to assign spin and parity of the band and concluded that the band head at energy 2536 keV is 8^-.

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