Search for tetrahedral symmetry in ^{158}Dy

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Introduction

A possible existence of nuclei with exotic shapes that resembles round-edged pyramids with triangular base (tetrahedral symmetry) has been a subject of number of works both theoretically as well as experimentally [1-5]. Calculations using realistic mean-field methods [3] suggest the existence of nuclear shapes with tetrahedral, *Td*, and/or octahedral, *Oh*, symmetries, sometimes at only a few hundreds of keV above the ground-states in some rare earth nuclei around ^{156}Gd and ^{170}Yb. Among all known double point groups, only three, i.e., tetrahedral, *Td* (‘‘pyramid like with triangular base’’), octahedral, *Oh* (‘‘diamond’’), and icosahedral (*Ih*) lead to ‘‘exotic’’ fourfold degeneracies of single-Fermion levels; all other symmetries lead to twofold degeneracies only. This high-degeneracy aspect leads to high stability of implied nuclear shapes, as it turns out [1]. Underlying single particle spectra manifest exotic four-fold rather than two-fold degeneracies. The associated shell-gaps are very strong leading to a new form of shape coexistence in many rare earth nuclei [3]. Interestingly, one only finds sizable tetrahedral deformation when the quadrupole deformation equals zero, as expected for a nucleus possessing exact Td symmetry [3]. Thus, tetrahedral shape is predicted to be intimately connected with vanishing quadrupole moments, and rotational bands based on such shapes are expected to have very weak, or vanishing, in-band E2 transitions, with multiple levels for each spin and parity [2].
In the present work, the aim is to measure the transition strengths [*B(E2)*s and *B(E1)*s] for the transitions in the band of interest. *i.e.* in proposed ***Td*** bands [1] in ^{158}Dy. *B(E2)* and *B(E1)* values can be calculated by measuring the lifetimes of the corresponding levels by the Doppler Shift Attenuation Method (DSAM).

Experimental Details and Data Analysis

Excited states in ^{158}Dy were populated by ^{150}Nd (^{12}C, 4n) ^{158}Dy reaction at a beam energy of 62 MeV. An isotopically-enriched ^{150}Nd target of ~ 700 μg/cm^2 thickness with ~ 5.63 mg/cm^2 Ta backing was used. The target was made by evaporation method using electron gun in High Vacuum Chamber in target laboratory at IUAC, New Delhi. The 62 MeV ^{12}C beam was provided by 14 UD BARC-TIFR Pelletron Accelerator facility. The de-exciting γ-rays were detected by the Indian National Gamma Array (INGA), at TIFR consisting of 15 clover detectors. The detectors were placed at 40°, 65°, 90°, 115°, 140° and 157° with respect to the beam direction. The list mode data was taken in double and higher folds by triggerless fast Digital Data AcQuisition (DDAQ) system [7]. A total of about 2.4×10^9 events were recorded in double and higher fold. The data was sorted using TIFR programs and analysed by using **RADWARE** and **CANDLE** programs.

The spectroscopy work is done for this nucleus [6], but the parity is assigned to ground state band only. We have gain-matched the data by calibrating it in CANDLE. Then Eγ-Eγ matrix is made using TIFR programs. Further analysis like symmetrization of matrix, projection, gating etc was done using RADWARE. The level scheme given in [6] is verified in our experiment and further analysis for assigning the spin &

parity to all levels is going on. In the present work, our main aim is to measure B(E1) values for 933 keV, 838 keV, 757 keV and 713 keV transitions through life-time measurement of associated levels by DSAM.

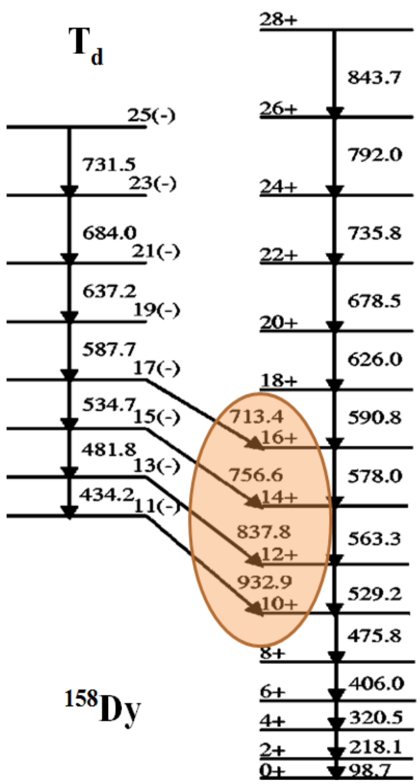

Fig. 1 Partial level scheme of ^{158}Dy residue populated via 4*n*-channel in ^{12}C+^{150}Nd interactions at 62 MeV.

Also measuring the B(E2) values of proposed Td band [1], shown in Fig.1 by using DSAM. If the suspected band is tetrahedral then the ratio of B(E2) value to B(E1) must be quite small as compared to the case of octahedral band. In order to extract this information the recorded gamma-ray spectrums have been gated by 218, 320, 406, 476 keV gamma-lines and summed up. The Fig.2 (a-b) shows the summed-gated gamma-spectrum and the gamma-lines of interest are visible and marked by arrows. The asymmetric Eγ-Eγ matrix is made for further analysis and detailed results will be presented during the symposium.

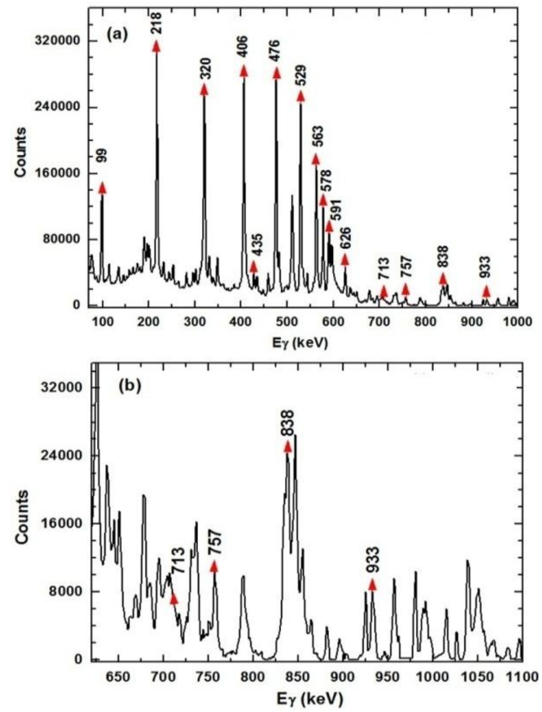

Fig. 2 (a-b) A γ-ray spectra obtained from the present experiment by summing the gates on 218, 320, 406, 476 keV γ-rays. (a) Shows all lines from main bands as well as from the proposed Td band. (b) Shows interconnecting lines (lines of interest in present work).

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