Novel Method of Lifetime Measurements in ^{156}Dy with Aerogel Backing

A. K. Sinha[1],* S.S. Bhattacharjee[1], R. Bhattacharjee[1], R. Raut[1], S. S. Ghugre[1], R.P. Singh[2], N. Madhavan[2], S. Muralithar[2], P.V. Madhusoodan Rao[3], M Kumar Raju[3], Krishichayan[4], L. Chaturvedi[4], S. Saha[5], J. Sethi[5], R. Palit[5], S. Mukhopadhyay[6], G. Smith[7], and R. V. F. Janssens[8]
[1] *UGC-DAE CSR, Kolkata Centre, Sector III, LB-8, Bidhannagar, Kolkata-700098, INDIA*
[2] *Inter University Accelerator Centre, Aruna Asaf Ali Marg, New Delhi-110067, INDIA*
[3] *Department of Nuclear Physics, Andhra University, Visakhapatnam 530003, INDIA*
[4] *Physics Department, G G University, Bilaspur, INDIA*
[5] *Deptartment of Nuclear and Atomic Physics, Tata Institute of Fundamental Research, Mumbai - 400005, INDIA*
[6] *Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai - 400085, INDIA*
[7] *School of Physics & Astronomy, University of Manchester, M13 9PL, UK and*
[8] *Argonne National Laboratory, Argonne, USA*

Introduction

Energy minima associated with high-rank symmetries, such as tetrahedral and octahedral, have been predicted to be feasible in atomic nuclei. Possibilities of atomic nuclei exhibiting tetrahedral symmetry is of general interest in relevant domains of quatum physics that usually invokes such symmetry in the context of molecules, metal clusters and fullerines. While the underlying interaction for the said objects is electromagnetic, nuclear tetrahedra is expected to be stabilized through strong interactions. Strong tetrahedral deformations were predicted around neutron / proton numbers 32, 40, 56, 64, 70, 90, 132-136 [1]. The experimental features for these bands were proposed [2] to be (i) of negative parity, (ii) weak intraband E2 transitions, (iii) expected around few hundred keV to few MeV above the ground state in the vicinity of ^{156}Gd and ^{160}Yb nuclei and (iv) dipole interband transition probabilities from the proposed tetrahedral bands to the ground state bands are expected to be considerably larger than the intraband E2 transition probabilities , particularly at the bottom of the tetrahedral band. Zealous efforts are underway around the globe for observing the tetrahedral symmetry in nuclei. In one such experiments recently carried out in GAMMASPHERE [3], negative parity bands in the ^{156}Dy (Z = 66, N=90) nucleus were investigated for possible tetrahedral shapes and the $K = 0^-$ band was indicated a possible candidate for the same. However, conclusive evidence of the same requires lifetime measurements that would provide stringent test for the phenomena. Experiments to measure lifetimes of negative parity bands in ^{156}Dy, carried out at GAMMASPHERE, indicated the lower lying band members of critical interest in the quest for tetrahedral structures, with lifetimes $\sim$ tens of picoseconds. Such order of lifetimes is in the limits of the conventional RDM or DSAM carried out using high Z backing. It was envisaged that the lifetimes in this range can be accessed if the recoils are allowed to stop in a medium with density more than that of air but less than a typical high Z backing (Au, 19.3 gm/cm^3). In the light of such considerations, aerogel was proposed to be used as backing material for lifetime measurements of negative parity bands in ^{156}Dy.

*Electronic address: aks@delta.iuc.res.in

Experimental Aspects

The target was ~ 400 μg/cm^2 of Nd_2O_3, enriched (~ 99.6%) in ^{148}Nd on a silica based aerogel backing of 8 mm thickness. The aerogel was commercially procured from Aerogel Technologies and had a quoted density of ~ 0.095 gm/cm^3. The ^{156}Dy nucleus was populated using the reaction $^{148}\text{Nd}(^{12}C, 4n)^{156}\text{Dy}$ at a beam energy of E_{lab} = 60 MeV. The β for the compound nucleus was 0.77%. The ^{12}C beam was provided by the 14 UD Pelletron at the Pelletron LINAC Facility in TIFR, Mumbai. The beam was completely stopped in the aerogel backing and reacted heavily with the Si in the aerogel material, as discussed later. Indian National Gamma Array (INGA), currently stationed at TIFR, was used as the detection system for the present measurements. During the present experiment, INGA had 19 Compton Suppressed Clover detectors with three detectors each at 40°, 65°, 115°, 140°, 157° and four detectors at 90°. Data was also acquired using a Ta backed enriched Nd_2O_3 target of similar thickness, inorder to provide a comparison for the data with aerogel backed target since this was probably the maiden instance in which aerogel backing was used in gamma spectroscopy measurements.

Data Analysis and Preliminary Results

The acquired data was sorted into angle dependent $\gamma - \gamma$ coincidence matrices. Two matrices have been constructed, one with all the detectors (except the back angle ones) in the x-axis and back-angle detectors in the y-axis while the other has all the detectors (except the forward angle ones) in the x-axis and the forward angle detectors in the y-axis. Gated spectra from the present measurements are illustrated in Fig. 1. Transitions from the ground state band of ^{156}Dy, 137, 266, 366, 445 keV are clearly observed in both the spectra, one corresponding to Ta backing (upper panel) while the other corresponding to aerogel backing (lower panel). Most interestingly, the 1046 keV transition that de-excites the

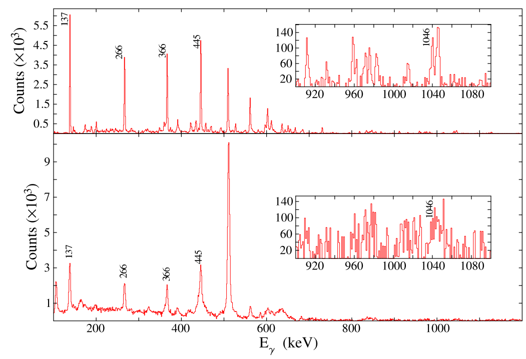

FIG. 1: A figure caption. Sum gate on 266 + 366 keV transitions in the gsb of ^{156}Dy. The upper panel corresponds to Ta backed data while the lower panel is from aerogel backed data.

$K = 0^-$ band, a candidate for tetrahedral deformation, to the ground state band, has been observed in the gated spectra. Analysis is in progress and directed towards observation of lineshapes / centroid shifts for transitions with known lifetimes (ground state band) in the aerogel backed data, as a reference, and then extending the same for the negative parity band. The prinicipal difference between the data acquired with the Ta backing and the aerogel backing is the many reaction channels that were populated in case of the latter owing to the interaction of the ^{12}C beam with the ^{28}Si in the aerogel material. Number of isotopes of Ar, S etc. in the A ~ 30-40 region were thus populated. These nuclei are charaterized by high energy γ-ray transitions that have substantially affected the background level in the aerogel backed data. Efforts are in progress to reduce this background by possible time gating techniques. The experimental results can be used as an indication for possible modifications in the experiments with aerogel backed targets.

References

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