Band structures in ^{116}Sb

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Introduction

The study of odd-odd nuclei around Z = 50 shell closure is interesting to study the collective as well as the single particle states. The odd-odd nuclei exhibit the combined features of odd proton and odd neutron. At low excitation energy, the nuclei around A~100 of this region, are expected to be dominated by the single particle excitations. It has been observed that the nuclei also exhibit collective structures that coexist with the single particle structures. With energy and angular momentum the collectivity develops, through the occupation of $h_{11/2}$ high-j negative parity orbital and also through the promotion of a proton from $g_{9/2}$ β-upsloping orbital into the β-downsloping $g_{7/2}$ orbital and thereby, leads the system towards the prolate deformation. The Sb isotopes, near Z = 50 magic shell closure, can provide an ideal laboratory for exploring the single as well as the collective structures within a single nuclear system. So far the information available on the structure of ^{116}Sb [1-3] is not enough compared to its neighboring isotopes. The aim of present work is to look for the near yrast structures of ^{116}Sb populated via α-beam and to look for the crossover E2 transitions for the previously predicted magnetic rotational band [3].

Experiment

The excited states of the ^{116}Sb has been populated using the reaction ^{115}In(α, 3n)^{116}Sb at a beam energy of 40 MeV from the K-130 Cyclotron at VECC, Kolkata. A self-supporting natural Indium (^{113,115}In) foil has been used as a target. The γ–γ coincidence events were detected with the high resolution gamma spectroscopy facility, the INGA array at VECC, comprised of 7 Compton suppressed Clover HPGe detectors placed at different angles with respect to the beam direction. Out of 7 detectors, 4 detectors were placed at 90°, 2 in backward 55° and 1 in forward at 40° angles with respect to beam direction. The target was placed 25 cm away from the aluminum face of the Clover detectors of the array. Under this condition a total of 200 million γ–γ coincidence events were collected and used for offline analysis.

Pre-amplifier pulse has been processed using PIXIE-16 digitizer based pulse processing and data acquisition system [4]. The data were collected in singles as well as in γ–γ coincidence mode. Standard ^{152}Eu and ^{133}Ba radioactive sources were used for calibration of detectors and to measure the efficiency of the detectors of the INGA array.

Analysis and Results

The time stamped listmode data was sorted using a set of programs, IUCPIX developed at UGC-DAE CSR, Kolkata [4] and the offline coincidence analysis is carried out using Radware software package [5]. A symmetric γ–γ coincidence matrix has been formed with the addbacks of all the 7 Clover detectors. Asymmetric matrices were formed to measure the DCO ratios using the backward and 90° detectors. The polarization asymmetry of the decaying γ-rays have been determined from a matrix of parallel and perpendicular scattering of the γ-rays using the 90° detectors. The preliminary results from the present experiment

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were reported earlier [6]. Present work extends the previously reported bands of ^{116}Sb [3] to higher angular momentum excitations. A total of 55 new γ-ray transitions were reported and placed in the level scheme. Earlier a band like structure of strong M1 transitions was observed, which was predicted to be a magnetic rotational band [3]. No crossover E2 transitions were observed in this band. In the present work, the corresponding E2 transitions of this band have been found and placed in the level scheme.

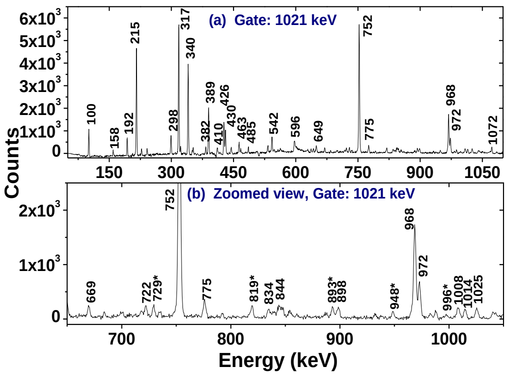

Fig. 1(a): Coincidence spectrum of 1021 keV (b): Expanded view of 1021 keV gate

Fig. 1(a) represents the coincidence spectrum of 1021 keV gate, connecting the said band to the yrast band. All the previously reported γ-rays which are in coincidence with 1021 keV can be observed from this spectrum. Fig. 1(b) represents the expanded view of Fig. 1(a), to show the newly observed E2 transitions, marked with '*'. The E2 nature of these transitions has been confirmed from the DCO ratio and polarization measurements. Fig.2 shows the transitions corresponding to band-2 of ^{116}Sb where the newly observed transitions are marked with '*'.

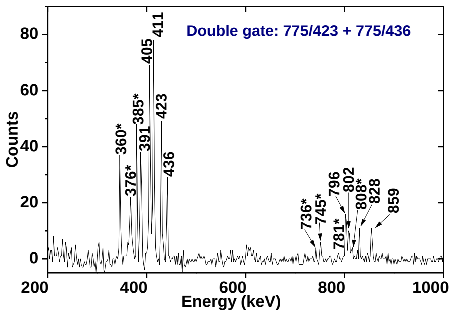

Fig. 2: Added double gates corresponding to band-2 from γ–γ–γ cube.

Discussion

Fig. 3 represents the alignment plot of the four different bands of ^{116}Sb which were reported earlier [3]. Here we report an extension of band 2 based on 7^+ ($\pi g_{9/2}^{-1} \otimes \nu d_{5/2}$) bandhead upto $J^\pi = 17^+$. The band is extended beyond the particle alignment at the crossing frequency of around 0.35 MeV. A large alignment gain of ~7ħ, as depicted in Fig.2, leads to a 4 quasi-particle configuration ($\pi g_{9/2}^{-1} \otimes \nu d^1_{5/2}\ h^2_{11/2}$) after the band crossing.

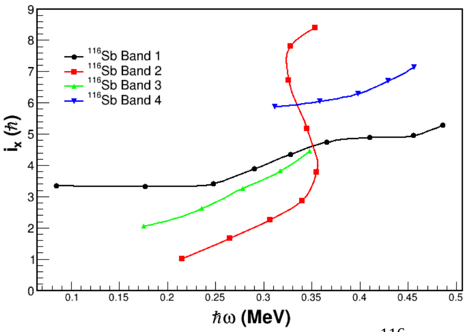

Fig. 3: Alignment plot for band 2 in ^{116}Sb. The Harris parameters are taken as $J_0 = 17\hbar^2$ MeV^{-1} and $J_1 = 12\ \hbar^4$ MeV^{-3} [3].

Summary

Around 55 new γ-rays in ^{116}Sb have been identified and placed in the level scheme. Five crossover E2 transitions have been observed and placed in the previously predicted magnetic rotational band [3] of ^{116}Sb.

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