First observation of the $\pi g_{7/2}$ band in ^{115}Sb

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Introduction

The structure of nuclei near Z=50 shell closure is important to study the coexistence of single-particle and the collective excitations. In this respect, Sb (Z=51) nuclei in A~110-120 region, with single valance proton above Z=50 shell gap and neutrons in the middle of Z=50-82 shell are the ideal testing ground to understand the interplay between these two kinds of excitations. Deformed band structures are observed at relatively higher spins, due to the proton excitation across Z=50 shell, whereas the low spin excitations are mainly due to the coupling of a valence proton in $g_{7/2}$, $d_{5/2}$ and $h_{11/2}$ orbitals with the Sn core [1-3]. Bands based on these orbitals were observed earlier in $^{117\text{-}119}$Sb isotopes [2]. In a recent study on ^{117}Sb, both the signature partners of the $\pi g_{7/2}$ band were also observed [3]. Therefore, the signature partners of $\pi g_{7/2}$ band is also expected to be observed in other odd-A Sb isotopes, including ^{115}Sb.

Excited states of ^{115}Sb were investigated earlier [4-6] using both light and heavy ion reactions. But the band structure based on $\pi g_{7/2}$ orbital has not been observed so far. In fact, the low lying structures are not explored much. The aim of the present work is to look for the $\alpha = \pm 1/2$ signature partners of $\pi g_{7/2}$ band in ^{115}Sb.

Experiment

The excited states of the ^{115}Sb have been populated in the present work, using the reaction ^{115}In(α, 4nγ)^{115}Sb with 52-MeV α beam from the K-130 Cyclotron at VECC, Kolkata. The target was a self-supporting foil of natural indium. The $\gamma\gamma$-coincidences were measured with a setup of 11 Compton suppressed clover HPGe detectors, placed at 90° (six), 125° (three), 40° (two), and 1 LEPS detector, placed at 40°. The detectors were placed at 25 cm away from the target.

The PIXIE-16 digitizer based digital data acquisition system [7] was used to acquire $\gamma\gamma$-coincidence and singles data. Standard ^{152}Eu and ^{133}Ba sources were used for energy calibration, efficiency of the detectors and for the correction factor for polarization asymmetry measurements.

Analysis and Results

The symmetric E_γ-E_γ coincidence matrix and the E_γ-E_γ-E_γ cube were formed from the addbacks of all the clover detectors. An angle-dependent asymmetric matrix, between 90^o and 125^o detectors was made to determine the multipolarity of the γ-rays. To extract the polarization asymmetry of the γ-rays, matrices corresponding to the parallel and perpendicular scattering in 90^o detectors were generated.

In the present work, several new transitions are observed and placed in the level scheme of ^{115}Sb. Representative coincidence spectra with single gate on the ground state transition 723-keV from the matrix and double gate on 723 and 1213 keV γ-rays from the cube are shown in Fig.1 and Fig.2, respectively. These spectra show the known as well as the new transitions in ^{115}Sb, observed in the present work. A new sequence of

E2 γ-transitions of energies 1213, 911, 727, 827 and 863 keV, in coincidence with each other and decaying to the $7/2^+$ state, has been observed. The presence of these transitions is clearly visible from double gate of 723 and 1213 keV, as shown in Fig.2. The quadrupole nature of these γ-rays is confirmed from their DCO (Directional Correlation from Oriented states) ratio. Several other γ-rays are observed in coincidence with the 723 keV ground state transition, confirming them as belong to ^{115}Sb. Further analysis is in progress to place these γ-rays transitions in the level scheme of ^{115}Sb.

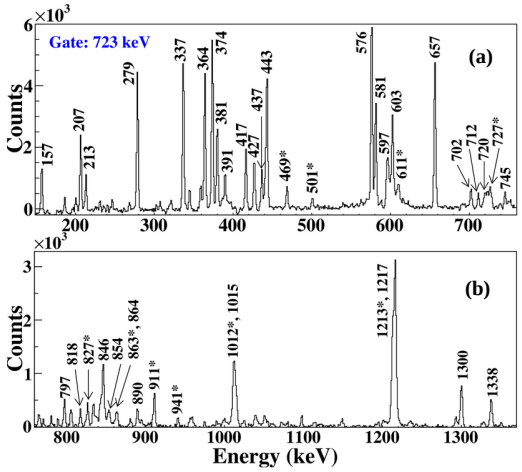

Fig.1: Coincidence spectra gated by 723 keV; (a) Lower energy (< 760 keV) part and (b) higher energy (>760 keV) part. Newly observed transitions are marked by '*'.

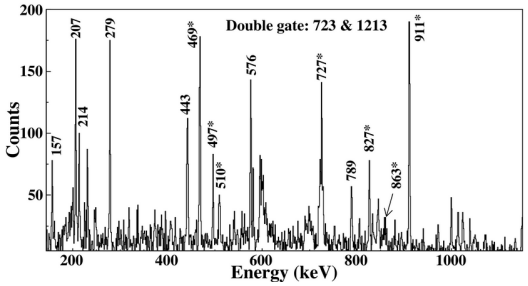

Fig.2: Double-gated spectrum with gates on 723 & 1213 keV, from the cube. The newly observed transitions are marked by '*'.

Discussion

The newly observed sequence of E2 transitions above 723 keV ($7/2^+$) level in ^{115}Sb is interpreted as the band based on $\pi g_{7/2}$ orbital. The excitation energy systematics of this sequence matched very well with those reported for the $\pi g_{7/2}$ band in the other Sb isotopes, as shown in Fig.3. The excited levels of the $\pi g_{7/2}$ band show a decreasing trend with increasing neutron number, while moving away from N=64.

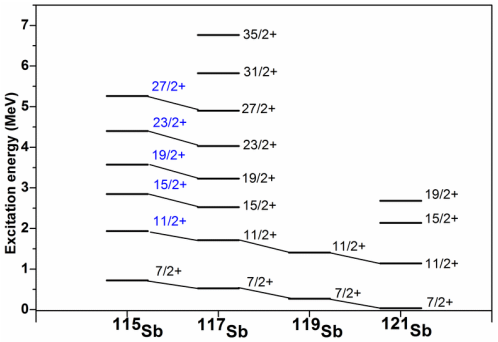

Fig.3: Systematics of the $\pi g_{7/2}$ band in Sb nuclei.

Summary

Excited states of ^{115}Sb have been investigated using induced fusion evaporation reaction and an array of Compton suppressed Clover detectors. Several new γ-rays in ^{115}Sb have been identified in ^{115}Sb from the coincidence relationships of the observed γ-rays. The $\pi g_{7/2}$ band in ^{115}Sb has been identified for the first time. Further analysis is in progress to look for the signature partner of the $7/2^+$ band.

Acknowledgment

We would like to thank the Cyclotron operators of VECC, Kolkata for their sincere efforts in providing a good quality Alpha beam. S. Dar acknowledges the financial support from UGC.

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