Identification of new partner bands based on $\pi g_{7/2}$ in ^{117}Sb

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Introduction

Nuclei with proton number near Z=50 and neutron number in mid shell are ideal candidates to study the competitive behavior of single particle excitations and collective rotations. Odd particle outside the Z=50 core is responsible for the proton single particle structures, whereas deformed band structures are generated mainly due to collective rotations involving mid shell neutrons. Odd mass Sb nuclei with neutrons in mid shell are known to exhibit these kind of single particle and collective behavior together. The low lying states in ^{117}Sb (Z=51, N=66) are originated from the coupling of the odd proton particle with the corresponding ^{116}Sn core [1]. Rotational structures based on proton orbitals available in 50-82 shell are reported in previous works of ^{117}Sb [2]. Rotational bands with 2p-1h configuration based on a $9/2^+$ state have been systematically observed in odd-A (A=113-119) Sb isotopes [3, 4]. Decoupled $\Delta I=2$ bands upon $7/2^+$, $5/2^+$ and $11/2^-$ bandhead have also been observed in ^{117}Sb [2].

Experiment

In the present study, Alpha induced reaction ^{115}In $(\alpha,2n)^{117}$Sb at a beam energy of 28 MeV, delivered from K-130 Cyclotron at VECC (Kolkata), was used to produce the excited levels of ^{117}Sb. The VECC Array for NUcler Spectroscopy (VENUS) [5] consisting of six Compton suppressed Clover HPGe detectors and a PIXIE-16 based digital data acquisition system [6] were used for recording the time stamped data in event by event mode in both singles and coincidence trigger conditions. The detectors are oriented in the median plane in the following way: one detector each at $\pm 30^0$, two detectors at 90^0 and one detector each at forward 45^0 and 55^0.

Analysis and Results

IUCPIX data sorting package [6] developed at UGC-DAE CSR (Kolkata Centre) was used to sort the time stamped data to form the Eγ-Eγ symmetric matrix and Eγ-Eγ-Eγ cube, which were used to extract various coincidence relationships between the γ-rays. A conventional DCO matrix having 90^0 detectors in one axis and another axis containing 30^0 detectors was also made to find the multi-polarities (Dipole/Quadrupole) of the γ-rays. The geometry of the two 90^0 detectors are utilized to find the IPDCO asymmetry parameters which helps to determine the electric/magnetic nature of the γ-ray.

Bands based on $\pi d_{5/2}$, $\pi g_{7/2}$ and $\pi h1_{1/2}$, which were seen in previous work using ^{11}B beam [2], is also seen in the present alpha induced reaction. Among these bands, the one based on $\pi g_{7/2}$ in ^{117}Sb is of interest in this

paper. Similar band is also seen in neighboring ^{119}Sb also [2]. From the present analysis this band is established as divided into two signature partner bands. In previous work [2] no specific information was available for these two bands (marked as band B1 and B1(a)). From DCO and IPDCO measurements the band B1(a) is confirmed as a ΔJ=2 band as its transitions are of E2 nature.

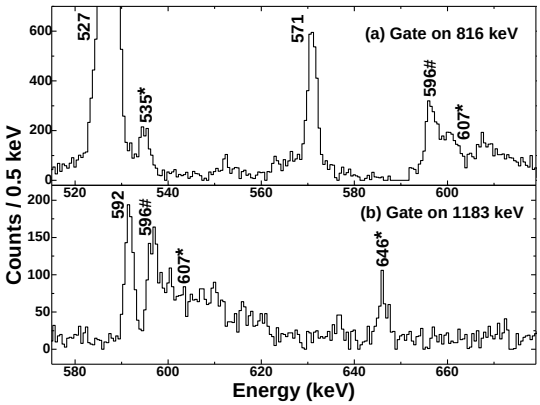

Fig 1 : Coincidence spectra corresponding to (a) 816 keV and (b) 1183 keV gate from γ–γ matrix. New connecting transitions are marked with '*'. Contaminations are marked with '#'

Three new γ-ray of energy 607, 535 and 646 keV are identified which decays from band B1(a) to band B1. On the other hand only one new γ-ray of energy 399 keV is found to decay from band B1 to B1(a). Fig. 1 shows the coincidence gate of 816 and 1183 keV transitions, where the observed connecting transitions are clearly seen.

Fig. 2 represents the Kinematic Moment of Inertia (KMoI) plots for above two partner bands. As can be seen from Fig.2 that the KMoI of the two bands are almost similar, which is one of the signatures for partner bands. It is also evident from the level energies of this two bands, these bands are having large energy staggering between the levels. Also a neutron pair alignment is seen at rotational energy ~ 0.4 MeV.

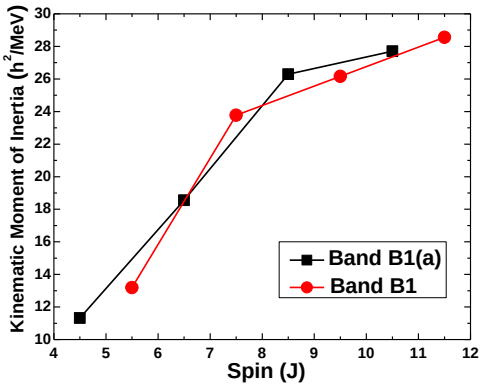

Fig 2 : Variation of Kinetic Moment of Inertia (KMoI) as a function of level spin for the two bands.

Theoretical Interpretations

The large basis shell model calculations with effective interaction SN100PN were carried out using the code OXBASH [7] to interpret the configuration of the band head. As per the calculations, the wave-function for the $7/2^+$ bandhead comes out to be of predominantly $g_{7/2}$ (~77%) character.

Particle Rotor Model (PRM) calculations [8] have also been carried out to reproduce the level structures of band B1 and B1(a). The bands are based on 7/2[413] Nilsson orbital and have a very little admixture of other orbitals. The initial results from this calculation are in reasonably good agreement with the experimental level energies and will be presented.

Reference:

[1] D. R. LaFosse *et.al.*, PRL, Vol. 69, No. 9 (1992)
[2] D. R. LaFosse *et.al.*,PRC 56,760 (1997).
[3] A. K. Gaigalas *et.al.*, PRL 35,555 (1975).
[4] R. E. Shroy *et.al.*, PRC 19,1324 (1979).
[5] S. Bhattacharya *et.al.*, Proceedings of the DAE-BRNS Symp. on Nucl. Phys. 61, 98 (2016).
[6] S. Das *et.al.*, NIM A 893, 138–145 (2018).
[7] Oxbash for Windows, B. A. Brown et al., MSU-NSCL report number 1289 (2004).
[8] S. Bhattacharya et al., PRC, 32, 1026, (1985).