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Study of $\pi h_{11/2}$ band in ^{113}Sb: A review

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Abstract

The πh11/2 band in 113Sb has been previously studied using different reactions with different excitation energies by different experimental group. The band was observed up to excitation energy 19146 keV with spin 75/2-. Lifetime has been measured upto 10217keV (51/2-)states. The measured B(E2) with spin shows the evidence of two alignments, one for a pair of neutron in h11/2 orbital and another for the pair of proton alignment in g7/2 orbital. Although the decrease in dynamic moment of inertia and decrease in B(E2) for the 47/2− and 51/2− states is interpreted as owing to a possible termination of the band at high spin in a non collective oblate state further investigations are required to find the lifetime measurement of the higher lying state to say anything conclusively about the smooth band termination of this band.

Keywords: *Nuclear Reaction, Doppler shift, Dynamic Moment of Inertial, smooth band termination*

1. Introduction:

An interesting feature of atomic nuclei is the process by which specific configuration manifest as collective rotational band at low and intermediate spin values, gradually loss their collectivity and terminate in a non-collective state at the maximum spin which can be generated within the configuration. Bands which shows a continuous transition from high collectivity to loss of collectivity with increase in spin is called smoothly terminating band. Several nuclei with 49≤Z≤53 in the 110 mass region have been found to possess □I=2 (I –Spin) rotational bands that are predicted to terminate with less collectivity at high spin [1,2]. The low energy state in this band arises due to excitation of g9/2 proton across the Z=50 shell gap to the down slopping g7/2d5/2 Nilson orbitals.This scheme gives the decoupled □I=2 band. This configuration is well known as 2particle-2hole (2p-2h) configuration. Rotational bands based on this 2p-2h excitation are reported in several Sn, Sb and Te isotopes [3,4,5]. The neutrons outside the 100Sn core are also distributed in the same orbitals with some occupying the h11/2 shell. Angular momentum is built from the gradual alignments of the extra core nucleons till the final states are formed, usually at a large energy cost. Afanasjev et al [6] have identified 40 bands in 18 nuclei in this mass region, with well-defined configurations that are expected to exhibit band termination, the phenomenon in which there will be gradual change of shape of the nucleus from the collective prolate to non-collective oblate at high spin. An important characteristics feature of smooth band termination is the large decrease in their dynamic moment of inertial J(2) to approximately a third of the rigid body value with spin as the rotational frequency approaches to 1 MeV/ .

The single-particle states in the odd-A antimony nuclei (Z = 51) represent the coupling of the valence proton in the g7/2, d5/2 and h11/2 orbitals to the spherical Sn (Z = 50) core . Here the collective states are produced through two ways, firstly due to excitation of proton from the g9/2 orbital leading to configuration which arises □I=1 band and secondly the coupling of the odd proton and the neutrons in the h11/2, g7/2 and d5/2 orbitals to the 2p-2h deformed core states of tin that result from the de-excitation of two protons from the high-□ g9/2 orbital to the low-□g7/2 and d5/2 orbitals which give □I=2 band. The low-lying excited states in Sb nuclei (Z = 51) show single-particle behavior. The valance proton in g7/2, d5/2 and h11/2 orbitals coupled to the spherical even Sn (Z = 50) core, are responsible for this behaviour. However, the high spin states are dominated by rotational behavior. These rotational states arise as a result of the coupling of the valance proton occupying g7/2, d5/2 and h11/2 orbitals with 2p-2h deformed Sn states. In this paper the aim is to study the πh11/2 band in 113Sb populated in different experiment since 90s.

2. Present status report

1. Janzen et al. [7] have reported □I = 2 band in 113Sb based on a πh11/2 orbital up to an excitation energy of 21.1 MeV and spin (79/2−) (the last state is tentative). A large average quadrupole deformation of β2 =0.32 has been reported . They carried out Nilsson-Strutinsky calculations of the potential

energy surfaces for Sb, which predict the existence of an excited h11/2 bandhead with prolate deformation of □2=0.28. The value of the quadrupole moment calculated using this deformation and assuming axial symmetry is 3.9 eb which is in excellent agreement of 4.4±0.6 eb as found from the Doppler shift attenuation analysis of the reaction 94Mo(23Na, 2p2n) reaction at a beam energy of 117 MeV beam provided by the Tandem Accelerator Super Conducting Cyclotron (TASCC) Facility at Chalk River Laboratories.

The increase in alignment (i) and the dynamic moment of inertia (J(2)) plot shown in Fig 3 in [7] two different band crossing at =0.46 MeV and 0.69 MeV respectively. The first band crossing has been interpreted as a pair of h11/2 neutron alignment. The corresponding gain in alignment calculated to be 7.5 Similar alignment has been observed in 110,112,114Sn but with different frequencies and larger interaction strength. The second band crossing is due to rotational alignment of g7/2 proton pair the corresponding gain in alignment calculated to be 4.5 .

2. The present group studied the πh11/2 band in 113Sb using in the 100Mo(20Ne, p6n) reaction at a beam energy of 136 MeV at the Variable Energy Cyclotron Centre, Kolkata [8], India.States up to spin (59/2-) and excitation energy of 12796 keV has been observed. Mean lifetimes for the five states (from 4460 to 7998 keV) were measured for the first time using Doppler shift attenuation method. An upper limit of the lifetime (0.14 ps) was estimated for the 9061 keV,47/2− state.The deformation is found to be 0.32 using the present lifetime and B(E2) calculation. The observed reduction in the experimental B(E2) values for the 918.4 keV (spin 39/2− → 35/2−) and 985 keV (spin 43/2− → 39/2−) transitions may be interpreted as due to the proton alignement in the g7/2 orbital [Table 2 in reference (8)]. The dynamic moment of inertia was observed to be about half of the rigid body value at the highest observed frequency.

3. The present group further studied the πh11/2 band in 113Sb using in the 100Mo(19F,6n) reaction at a beam energy of E = 105 MeV at the 15UD Pelletron Accelerator at the Inter University Accelerator Centre (IUAC), New Delhi [9]. In addition, two higher-energy states with excitation energies of 17369 and 19146 keV (Fig. 1 in ref [9]) and decaying through the 1650 and 1777 keV transitions, respectively, are tentatively proposed to extend this band up to a spin of 75/2−. It may be noted here that the energies of the two highest transitions are significantly different compared to those reported by Janzen et al.[7]. The average quadrupole moment Qt = 4.77 ± 0.50 obtained in this work for the eight states up to 10217 keV is consistent with [8] and also with that reported by Janzen et al. [7] within errors.

Figure 6 in Ref[8] shows a plot of the quadrupole moment Qt as a function of level spin for the πh11/2 band in 113Sb. The plot provides an indication of the vh11/2 alignment that occurs at a rotational frequency of 0.46 MeV. The dynamic moment of inertia J(2) for the band shows a second alignment at 0.69 MeV, associated with the rotational alignment of g7/2 protons. Following this alignment, the J(2) values decrease for the highest observed state. The lifetime measurement for the higher lying states could not measure due to lack of statistics. So firm conclusion for the band termination not yet onclusively inferred in the all three individual studies.

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