Deformed shapes in odd-odd nuclei near Z = 82

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Introduction

The neutron deficient nuclei in the vicinity of the Z = 82 region are known for interesting structural phenomena arising due to different shape driving effects of the proton and neutron orbitals near the Fermi surface. It has been found that the heavier bismuth and thallium nuclei with A > 200 are spherical and the lighter nuclei with A < 194 have rotational bands indicating deformation [1 - 3]. The excitation energies of the proton intruder levels, $\pi s_{1/2}$ for Bi and $\pi h_{9/2}$ for Tl nuclei, have been observed to decrease with the decrease in neutron number as these intruder proton levels has shape driving effect towards oblate deformation. On the other hand the neutron orbitals near the Fermi level have prolate driving effect. Recently some indication of onset of deformation at N = 112 has been found from the theoretical and experimental investigation of ^{195}Bi [4]. A small deformed (prolate) shell gap at N = 112 apparently triggers this onset of deformation. It is interesting to study the effect of this two opposite shape driving effects in an odd-odd nucleus. Moreover, the $\Delta L = 3$, $\Delta J = 3$ levels $\nu f_{7/2}$ and $\nu i_{13/2}$ are accessible to the odd-neutron in light Bi isotopes. So the octupole correlation will be enhanced and its effect in stabilizing the shape of these nuclei can be studied.

We report here our recent experimental investigation of γ-ray spectroscopy of odd-odd Bi and Tl nuclei in mass region A = 190.

Experimental Details

Excited states of the $^{196-198}$Bi and ^{194}Tl have been populated via the fusion-evaporation reactions ^{nat}Re(^{16}O,xnypγ) at 112.5 MeV of beam energy from the 15-UD Pelletron at IUAC, New Delhi, India. The target was a thick (18.5 mg/cm^2) natural rhenium target. The isotopic ratio of ^{185}Re and ^{187}Re in the natural rhenium is 37:63. The ^{198}Bi and ^{194}Tl nuclei were produced in this reaction in the 3n/5n and the α3n channel. The γ–γ–γ data were taken in the list mode using INGA detector array consisted of 15 Compton suppressed clover HPGe detectors at the time of the experiment. The data were sorted into γ-γ matrix and γ–γ–γ cube. The INGASORT and the RADWARE codes were used for the analysis. The detailed analysis is in progress and the result of preliminary analysis is reported here.

Results and Discussion

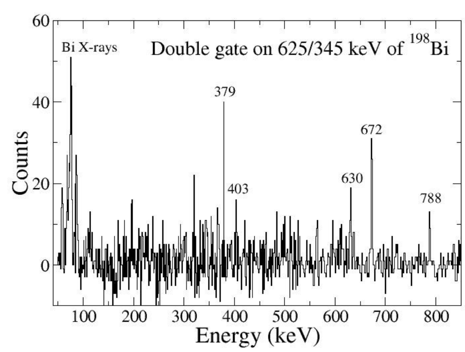

Fig. 1 Double gated spectrum of ^{198}Bi obtained from the γ–γ–γ cube analysis.

The high spin spectroscopy of ^{198}Bi has been studied earlier by using 6 HPGe detectors [5]. The level scheme is known up to about 3.9 MeV of excitation energy and tentatively up to

20ħ of angular momentum. All the known gamma rays, albeit small count, of ^{198}Bi could be observed in the double gate put in the cube analysis as shown in Fig 1. The counts in the single gated spectra are almost 2 orders of magnitude more than the double gated spectra. Detailed analysis was, therefore, done mostly using the γ–γ matrix. Many new gamma transitions were identified in both the nuclei ^{194}Tl and ^{198}Bi. A rotational band was identified in ^{194}Tl way back in 1979 with two Ge(Li) detectors [6]. The coriolis coupled rotational band was placed above the 8^+ state but the band head spin was not known. The γ-rays belong to this band have been observed in our data along with the indication of a new rotational band. Comparing with the neighboring nuclei, these bands may be attributed to the $\pi h_{9/2} \otimes \nu i_{13/2}$ configuration. The detailed analysis is in progress.

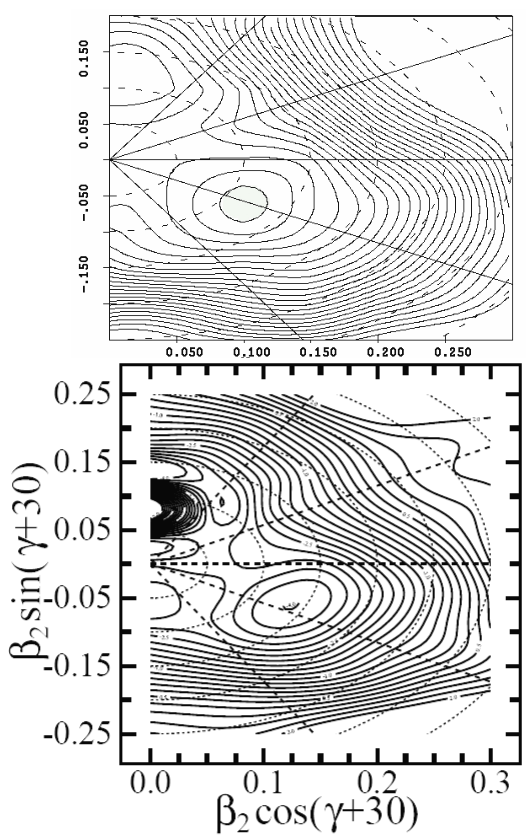

Fig. 2 Calculated potential energy surface of ^{198}Bi (top) and ^{194}Tl (bottom). See text for detail

The potential energy surface calculations using Woods-Saxon potential have been performed for these nuclei. The calculations are done with the odd neutron in the $\nu i_{13/2}$ orbital while the proton in the intruder level i.e $\pi s_{1/2}$ for ^{198}Bi and $\pi h_{9/2}$ for ^{194}Tl. The calculations show well developed stable minima at the oblate deformation (γ = -60^o) for both the nuclei in this configuration as shown in Fig 2. The top panel in Fig 2 is for ^{198}Bi and the bottom one for the ^{194}Tl. The separation between the contours is 250 keV. It indicates that the oblate driving intruder $\pi s_{1/2}$ and $\pi h_{9/2}$ orbital induces the oblate shape in these nuclei and the odd neutron seems to remain spectator in determining the shape.

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