Low-lying Band Structure in ^{149}Pm Nucleus

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Introduction

The well established rotational bands in atomic nuclei might be distorted due to the long-range correlation force arising from the interaction of the valence protons and/or neutrons outside the closed shells [1]. For specific combination of proton and neutron numbers, these additional correlation interactions lead to a reflection asymmetric structure, called as octupole shape ("pear-shape") [2]. Specifically, in A $\approx$ 150 mass-region, the existence of $g_{7/2}$ normal orbital and $i_{13/2}$ intruder orbital builds an ideal platform to find the octupole collective structure. So far, octupole collectivity has been observed in many nuclei such as ^{152}Gd, ^{150}Sm, ^{152}Ce, ^{144}Ba, and etc.

In the most recent spectroscopic measurements of ^{149}Pm nucleus, two signature partner parity doublet bands were identified and extended upto 23/2 $\hbar$ state [3]. They also reported the crossover *E1* transitions interlinking the two opposite parity bands. However, the lower values of the intrinsic dipole moment suggest the presence of weaker octupole correlations than its neighboring isotones ^{148}Nd, ^{150}Sm with N = 88. Apart from this, much information related to the low-lying structural properties of this nucleus is limited. So, the present work primarily focuses on developing the low-lying band structure in ^{149}Pm nucleus using various spectroscopic techniques.

Experimental Details

The excited states of ^{149}Pm were populated through the ICF reaction in which ^{7}Li projectile with 30-MeV energy was bombarded on ^{148}Nd target of thickness 750 μg/cm^2 backed with 10 mg/cm^2 gold. The ^{7}Li beam is fragmented into ^{3}H and α charge fragments. The energies of the charge fragment depends on mass number A, hence the ^{3}H and α fragments acquired an energy of $\approx$ 13 MeV, and $\approx$ 17 MeV, respectively. The de-exciting γ-rays were detected using sixteen Compton-suppressed clover detectors and two low energy photon (LEPS) detectors during the experiment. After calibration and gain matching of individual crystals, add-back spectra were generated for all the clovers, and the coincidence data were stored in a $\gamma - \gamma$ matrix. The RADWARE software package was used for

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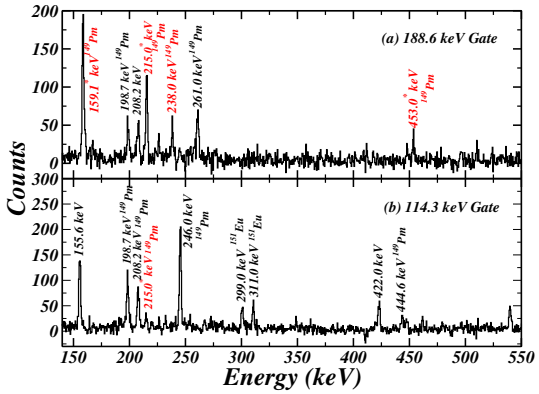

FIG. 1: A portion of the background subtracted spectrum gated on (a) 188.6 keV transition (b) 114.3 keV transition.

the analysis of the matrix. The detailed analysis is in progress.

Results and Discussion

In the present study, the level structure of ^{149}Pm has been upgraded by adding two new signature partner bands with five new transitions having 159.1, 215.0, 238.0, 333.1, and 453.0 keV energies respectively. The representative spectra with gate at 188.6 and 114.3 keV transitions, confirming these transitions are shown in Fig. 1. The band head of the new band is at $7/2^+$ state with an excitation energy of 348 keV. One new excited $(11/2^-)$ state, decaying via 510.0 keV γ- transition,has also been placed above the negative parity $7/2^-$ state. Further an ΔI = 1 transition with 221.6 keV energy has also been placed between $(11/2^-)$ and $9/2^+$ states.

The spin and multipolarities of the γ-rays transitions were assigned through the directional correlation of oriented nuclei states (DCO) ratio measurements using the following relation [4]

$$R_{DCO} = \frac{I_{\gamma 1} \text{ observed at } 148^\circ \text{ gated on } \gamma_2 \text{ at } 90^\circ}{I_{\gamma 2} \text{ observed at } 90^\circ \text{ gated on } \gamma_2 \text{ at } 148^\circ} \quad (1)$$

where the I_γ denotes the intensity of the γ- rays. In the present measurements, the DCO ratio for the band structure has been measured up to (11/2) state using 114.3, 159.1, and 188.6 keV transitions gates. Based on their R_{DCO} values, multipolarity of crucial 156.2, 208.2, 198.7, and 215.0 keV transitions were established as dipole in nature. While, the measured multipolarity of 114.3, 246.0, and 238.0 keV transitions suggest ΔI=1, M1 /E2 mixed character. Similarly, the other γ-ray transitions of band I were assigned as quadrupole in nature based on their R_{DCO} values.

In low-spin structure, the previously reported $9/2^+$ state has now been assigned as $11/2^+$ state based on the R_{DCO} = 1.04 (14) value of the decaying 288.5 keV transition. The R_{DCO} values also established the quadrupole nature of 490.8, 509.5, and 450.2 keV transitions present in the band built on this spin state. Further, the crucial 261.4 and 254.3 keV transitions, decaying from $17/2^{(-)}$ to $15/2^-$ and $21/2^{(-)}$ to $19/2^-$, respectively, have been assigned as dipole transitions. The dipole nature of the 366.4 keV transition, decaying from the negative parity to positive parity band, has also been identified using the R_{DCO} value (=0.54(0.17)). Further, the band structure has been interpreted using total Routhian surface (TRS) calculations where its γ- softness nature has been confirmed. A prolate (γ = 0°) minimum at low frequency $\hbar\omega$=0.00 MeV has also been obtained which changes to the single particle structure after the band crossing at $\hbar\omega$=0.350 MeV for positive parity positive signature bands. Thus, the present measurements introduce significant modification in the band structure of the low-lying states in ^{149}Pm.

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