High spin negative parity states in ^{135}Pr

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Introduction

Regular bands consisting of strongly enhanced $M1$ transitions along with weak or unobserved $E2$ crossover transitions were reported throughout the Pb region. To explain these bands, Magnetic Rotation (MR) phenomenon was suggested [1]. Since then, several nuclei across different mass regions have been investigated to search for MR bands. Particularly, across $Z = 59$ odd$-$A nuclei like ^{133}Pr and ^{137}Pr, high spin negative parity bands have been identified as MR bands [2, 3]. A band structure similar to the above mentioned $M1$ band has been tentatively reported in ^{135}Pr isotope [4]. In the present work, this band structure has been explored for MR. The theoretical interpretation has been done using Tilted Axis Cranking (TAC) calculations in the framework of hybrid model [5].

Experimental Details

High spin states in ^{135}Pr were populated using the ^{123}Sb(^{16}O,4n)^{135}Pr reaction at an incident beam energy of 82 MeV from the pelletron accelerator of Inter University Accelerator Centre (IUAC), New Delhi. The ^{16}O beam was incident on 800 μg/cm^2 of ^{123}Sb target on a 10 mg/cm^2 thick ^{197}Au backing. The deexciting $\gamma-$rays were detected by the Indian National Gamma Array (INGA) which consisted of 15 Compton suppressed clover HPGe detectors placed at 32°, 57°, 90°, 123°, 148° with 3, 2, 4, 2 and 4 detectors respectively. The list mode data were taken in triple and higher fold $\gamma-$ray coincidence. The data were sorted and analyzed using INGASORT and RADWARE program, respectively.

Results and Discussion

A partial level scheme consisting of band 3 [6] is shown in Fig. 1. This band has been extended up to 7111 keV by tentatively placing a transition of 604 keV. Spins and parities of excited nuclear energy levels in this band were obtained by Directional Correlations of Oriented states (DCO) and Integrated Polarizational Directional Correlation (IPDCO) methods, respectively. The $R_{\rm DCO}$ is obtained from the following formula :

$$R_{\rm DCO} = \frac{I(\gamma_1) \text{ at } 148^\circ \text{ gated by } \gamma_2 \text{ at } 90^\circ}{I(\gamma_1) \text{ at } 90^\circ \text{ gated by } \gamma_2 \text{ at } 148^\circ}.$$

Figure 2 shows a coincidence spectrum obtained from the sum of double gated spectrum gated on 424- and 373-, 660-, 854-, and 1000-keV γ-ray transitions. It shows various transi-

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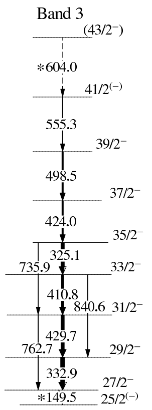

FIG. 1: Partial level scheme of ^{135}Pr. New γ-rays are marked with an asterisk.

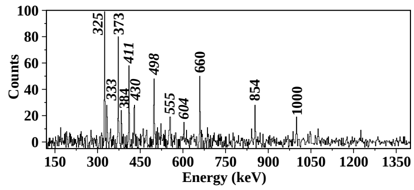

FIG. 2: Summed double gated spectrum. Transitions of 373-, 660-, 854- and 1000-keV belong to the yrast band. Transitions belonging to band 3 are marked in italics.

tions belonging to the negative parity $\Delta I = 1$ band 3. The R_{DCO} and polarization asymmetry (Δ) values establish $M1$ character for most in-band transitions of band 3 as given in Table I. The observed behaviour of spin (I($\hbar$)) as

TABLE I: γ-ray energies E_γ, R_{DCO}, and polarization asymmetry Δ for transitions of band 3.

E_γ	R_{DCO}	Δ
149.5	$0.50(4)^a$	
325.1	$1.28(5)^b$	-0.12(6)
332.9	$0.47(3)^a$	-0.03(8)
410.8	$0.51(7)^a$	-0.16(10)
424.0	$0.33(4)^a$	-0.15(9)
429.7	$0.45(3)^a$	-0.05(6)
498.5	$0.83(4)^b$	-0.14(7)
555.3	$0.87(14)^b$	

^{a}Quadrupole gating transition.
^{b}Dipole gating transition.

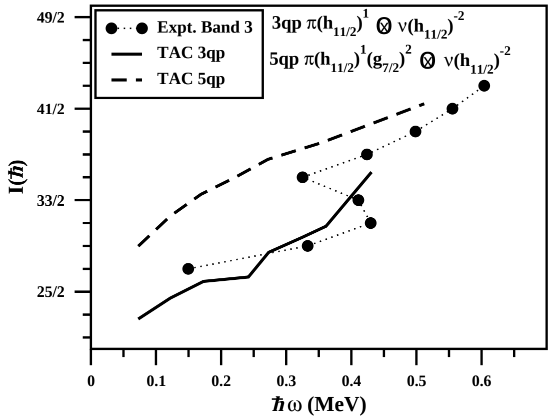

FIG. 3: I($\hbar$) vs $\hbar\omega$ behaviour.

a function of angular frequency ($\hbar\omega$) is shown in Fig. 3 for band 3. From this experimental behaviour it can be seen that band crossing occurs at $\hbar\omega \approx 0.37$ MeV due to the breakup and alignment of $g_{7/2}$ proton pair. In order to interpret the structure of band 3, TAC calculations have been performed by using a 3qp and 5qp configuration for the lower and upper part of the band, respectively. The results of our TAC calculations are shown in Fig. 3 and these show a good agreement with the observed data.

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