# High spin structure of $^{135}$Pm

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## Introduction

The rare earth nuclei in A∼135 mass region near proton drip line are predicted to be soft with respect to deformation parameter $\gamma$. These nuclei have been shown to exhibit sudden onset of deformation and other collective features at higher excitation energies. Indeed the investigation on the effect of quantal rotation on nuclear structure will provide valuable insight into their shape evolution and a suitable laboratory to test present nuclear models.

In odd-proton $^{135}$Pm nuclei, Fermi surface lies near the bottom of the $h_{11/2}$ shell. The yrast band is based on $[541]\frac{3}{2}^-$ configuration. The alignment of valence $h_{11/2}$ odd-proton in the observed rotational bands is expected to shed some light on shape transition. The shape coexistence have been observed in neighbouring odd-A La [1], Pr [2], Pm [3],[4] nuclei which are built on quasiproton configurations. A detailed study is required on high spin states of $^{135}$Pm to further probe the collectivity, single-particle excitations and establish the level scheme.

## Experimental Details and Results

High Spin excited states of $^{135}$Pm were populated using the heavy ion fusion evaporation reaction $^{107}$Ag($^{32}$S, 2p2n) at INGA array in Tata Institute of Fundamental Research, Mumbai. The 145 MeV $^{32}$S beam was provided by TIFR-BARC Pelletron facility at TIFR. The $^{107}$Ag self-supporting target of thickness 0.95 mg/cm$^2$ was used. The beam current was maintained at 9 nA. The de-exciting gamma-rays were detected using the setup consisting of 11 Compton-suppressed HPGe clover detectors which were arranged in the rings at 23°, 90°, 140°, and 157° with respect to the beam direction[6]. Two and higher-fold coincidence events were recorded in a fast digital data acquisition system (DDAQ) based on Pixie-16 modules of XIA-LLC which provides both energy and timing information. The data was calibrated using mixed radioactive source of $^{133}$Ba and $^{152}$Eu and were sorted using MultipARameter time stamped based COincidence Search (MARCOS) [6] program to generate one-dimensional histograms, $E_\gamma$-$E_\gamma$ matrix, and $E_\gamma$-$E_\gamma$-$E_\gamma$ cube for offline analysis. RADWARE software package [7] were used for subsequent analysis.

The previous level scheme of $^{135}$Pm was extended up to the excitation energy of 8.99 MeV and spin $55/2\hbar$ with 20 new transitions. The yrast band is shown in Fig. 1 and the associated doubly gated coincidence spectrum is depicted in Fig. 2. Two of the several new transitions with energy 1087 keV and 1154 keV have been identified which decay into $47/2^-$ level. The spin and parity were determined using Directional Correlations of de-exciting Oriented states (DCO) and polarization asymmetry ( $\Delta_{asym}$) method. The DCO ratio and $\Delta_{asym}$ values of the observed transitions were measured and is shown in Fig.3. $R_{DCO} \sim 0.5$ (1) corresponds to

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pure stretched dipole (quadrupole) transitions gated with quadrupole transition. The electromagnetic nature is determined by linear polarization measurements where positive (negative) $\Delta_{asym}$ values represent electric (magnetic) character. The energy, spin and parity assignments of this band are consistent with the earlier results [4],[5].

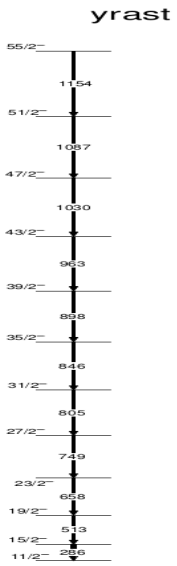


FIG. 1: Partial level scheme of $^{135}$Pm

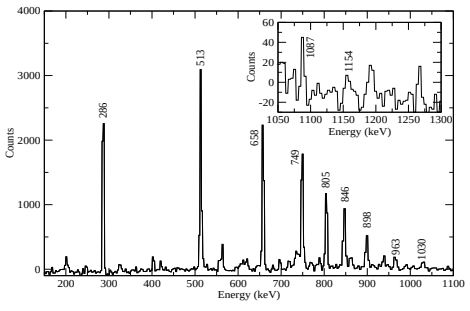


FIG. 2: Spectrum obtained from the double gate on 286 keV and 513 keV transitions.

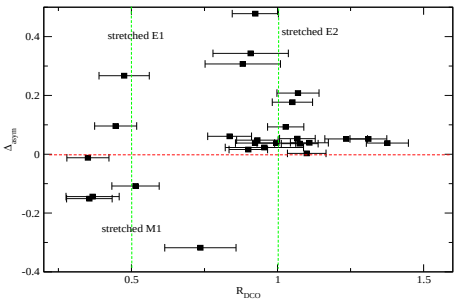


FIG. 3: Experimental $\gamma$-ray asymmetry parameter ($\Delta_{asym}$) plotted against the $R_{DCO}$.

## Summary and Conclusion

High spin states of $^{135}$Pm have been studied. Spin and polarization values of new transitions have been reported in this work. The details of the new level scheme will be presented. The triaxial projected shell model calculation is in progress to understand the configurations of different band structures in this nucleus.

## References

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