Negative-parity high-spin band structure in ^{135}Pr

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The phenomenon of magnetic rotation (MR) [1] was discovered when rotation-like bands of strongly enhanced magnetic dipole ($M1$) γ-ray transitions were observed in spherical or near-spherical nuclei. The dominant feature of these bands is that high-j, low-Ω proton particles (holes) and high-j, high-Ω neutrons holes (particles) or vice versa couple to form two long spin vectors j_π and j_ν, adding up to a total spin J of the nucleus. Such a coupling gives rise to enhanced $M1$ transitions. This phenomenon was first observed in $A = 190$ mass region across the isotopic chain of Pb nuclei. It was found that the MR bands in these nuclei are associated with high-j proton excitations coupled to high-j neutron hole states i.e. $[\pi(h_{9/2}i_{13/2}s^{-2}_{1/2})11^- \otimes \nu i^{-n}_{13/2}]$, $n = 1, 2, 3$ and different configurations of the neutrons in the pf orbitals. This discovery of rotational-like sequences of γ-ray transitions led to the search of MR bands in other mass regions near closed shells where high-j nucleons are available.

In $A \sim 135$ mass region, MR bands are expected as high-j low-Ω $h_{11/2}$ proton and high-Ω $h_{11/2}$ neutron orbitals lie near the Fermi surface and nuclei have small core deformation. Several $\Delta I = 1$ bands built on multi-quasiparticle configurations have been found across some nuclei in this mass region [2, 3]. These bands involved $h_{11/2}$ protons and neutrons. Further investigation of these bands and the observation of new $\Delta I = 1$ bands revealed that they could be interpreted as arising due to the phenomenon of MR. In the present work, a dipole band structure in ^{135}Pr has been investigated for the phenomenon of MR.

The experiment to populate high spin states in ^{135}Pr was performed at Inter University Accelerator Centre (IUAC), New Delhi, with a 82 MeV ^{16}O beam from the pelletron accelerator being incident on a target consisting of 800 μg/cm^2 ^{123}Sb with 10 mg/cm^2 ^{197}Au backing. The γ rays emitted in the reaction were detected using the Indian National Gamma Array (INGA), which consisted of 15 Compton-suppressed clover detectors. Data were taken in triple and higher fold γ-ray coincidence. The data were sorted and analyzed using INGASORT and RADWARE programs, respectively.

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A partial level scheme [4] has been established for negative parity states. In the negative parity level structure, several new γ-ray transitions have been identified and placed. Among higher spin states, a dipole band has been reported. It consists of $M1$ transitions ($M1(\Delta\ \mathrm{I} = 1)$) nature established by Directional Correlations of Oriented states (DCO) and Integrated Polarizational Directional Correlation (IPDCO) methods.). The crossover $E2$ transitions in this band have been observed for the first time. A band crossing has been seen at $I \approx 35/2^{-}\ \hbar$ and $\hbar\omega \approx 0.37$ MeV. The experimentally observed properties have been interpreted in terms of the Tilted Axis Cranking (TAC) model [5]. For the TAC calculations, a 3qp configuration and a 5qp configuration have been considered for the lower and upper parts of the band, respectively. A good agreement between the I versus $\hbar\omega$ experimental data and theoretical calculations supports the proposed configuration assignments to this band.

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