Rotational structures in the $^{125}$Cs nucleus

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Abstract. The collective band structures of the $^{125}$Cs nucleus have been investigated by in-beam $\gamma$-ray spectroscopic techniques following the $^{110}$Pd ($^{19}$F, 4n) reaction at 75 MeV. The previously known level scheme, with rotational bands built on $\pi_{7h_2/2}$, $\pi_{g_9/2}$ and $\pi_{h_{11/2}}$ orbitals, has been extended and evolved into bands involving rotationally aligned $\nu(h_{11/2})^2$ and $\pi(h_{11/2})^2$ quasiparticles. A strongly coupled band has been reassigned a high-$K$ $\pi h_{11/2}$ multiplet and a new side band likely to be its chiral partner has been identified. Configurations assigned to various bands are discussed in the framework of Principal/Tilted Axis Cranking (PAC/TAC) model calculations.

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The $^{125}$Cs isotopes lying in the transitional region above the $Z = 50$ and below the $N = 82$ shell closures are predicted to possess relatively flat potential-energy surfaces with respect to the quadrupole shape asymmetry parameter ($\gamma$) [1]. The triaxial deformation in this mass region has been evidenced by interpretation of observed crossing frequencies, staggering behaviour and $\Delta I = 1$ doublet bands, which have been explained as the manifestation of chirality [2]. Chiral bands have been observed in various odd-A [3] and odd-odd nuclei [4] with multiquasiparticle configurations that have substantial angular momentum components along the three principal axes. Another important feature is the magnetic dipole bands generated through the shear mechanism and have also been reported in the odd-A $^{131}$Cs [5] and doubly odd $^{132}$Cs isotopes [4]. Among the $^{55}$Cs isotopes, band-terminating states have been recently observed in $^{123}$Cs at $I \sim 30\hbar$ [6]. The present in-beam gamma spectroscopic investigations are planned to probe for the above-mentioned structural features in the $^{125}$Cs nucleus.

The excited states in the $^{125}$Cs nucleus were populated using the $^{110}$Pd ($^{19}$F, 4n) fusion-evaporation reaction at $E_{lab} = 75$ MeV. The $^{19}$F ion beam was delivered by the 15 UD pelletron accelerator at the Inter-University Accelerator Centre (IUAC), New Delhi. The target consisted of a self-supporting 1 mg/cm$^2$ thick $^{110}$Pd foil. The emitted $\gamma$-rays were detected using the Gamma Detector Array (GDA) comprising of 11 Compton-suppressed Ge detectors, one unsuppressed clover detector and a 14-element BGO multiplicity filter. The Ge detectors were mounted in three groups of four each making angles of 45°, 99° and 153° with the beam direction and having an inclination of ±23° with the horizontal plane. A total of 500 million coincidence events were collected in the experiment. Nuclides with major population in the reaction were $^{124}$Cs (~25%), $^{125}$Cs (~50%) and $^{124}$Xe (~10%).

In the off-line analysis, the recorded coincidence data were sorted into $4k \times 4k E_{\gamma} - E_{\gamma}$ matrices. RADWARE graphical-analysis package [7] was used to establish coincidence and intensity relationships for various gamma transitions. The dipole/quadrupole nature of the $\gamma$-ray transitions was inferred from angular-correlation analysis based on the DCO method, which helped in level-spin assignments. The level scheme of $^{125}$Cs is shown in fig. 1 with the band structures labeled 1-8.

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The spin and parity of the ground state ($t_{1/2} = 46.7 \text{ m}$) have been assigned $I^g = 1/2^-$ by Arlt et al. [8] from the EC decay of $^{125}\text{Ba}$. The earlier-known level schemes [9, 10] established through in-beam spectroscopy following fusion-evaporation reactions have been substantially extended up to $I = 59/2^+$ with the addition of about 40 transitions. The present level scheme preserves major features of the previous level schemes [9, 10], which revealed rotational structures based on the $\pi \hbar_{11/2}$ (band 1), the $\pi \hbar_{11/2} \otimes \gamma$ vibrational band (band 2), $\pi g_{9/2}$ (band 5) and $\pi g_{7/2}$ (band 6) orbitals, a coupled band 3 that was assigned the $\pi g_{7/2} \otimes \nu h_{11/2} \otimes \nu g_{7/2}$ configuration and band 8. The negative-parity band 1 built on an $I^g = 11/2^-$ isomeric state ($t_{1/2} = 0.90 \text{ (3 m)}$, excitation energy = 267 keV) is most intensely populated. The decay of this isomer has been adopted from the studies by Sugawara et al. [11]. Band 3 comprises strong dipole transitions along with weak $E2$ crossover transitions. It decays into the states of band 1 through high-energy dipole 1688, 1119 and 766 keV transitions. The present DCO analysis also confirms the previously established [10] dipole nature of these transitions. Several new states de-exciting to both the signatures of the coupled band 3 form a new side band 7. This band is composed of a regular sequence of low-energy transitions (likely to be $M1$) which are weak compared to the interband transitions to band 3. The $\gamma-\gamma$ coincidence spectrum for these bands is shown in fig. 2. A newly observed sequence of transitions (likely to be $E2$) is shown as band 4 in fig. 1. The decay of this band is fragmented, mostly connecting to the low-lying states with