Spectroscopic investigation of ^{140}Eu

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Spectroscopic investigation of weakly deformed nuclei in A $\sim$ 140 mass region with Z $\sim$ 64 and N $\sim$ 82 has generated considerable interest because they exhibit large variety of excitation mechanism. The available particles and holes in the high j-orbitals $\pi h_{11/2}$ and $\nu h_{11/2}$ in nuclei of this mass region enable us to search for different exotic mechanisms like shape co-existence, shears mechanism, octupole correlation, and chiral symmetry breaking phenomenon in their excited spectra.

It is noteworthy that the planar shears bands have been observed in many nuclei [1] and the chiral twin bands, which are the manifestation of the triaxial deformed shape, are observed up to $N = 77$ for ^{132}Cs ($Z = 55$) and up to $Z = 63$ for ^{138}Eu ($N = 75$) [2]. The recent investigations of the island of nuclear chirality seems to indicate that the $N = 77$ isotones form the border of the island, when the neutron number approaches $N = 82$ [3]. Therefore, it is interesting to see whether this conjecture holds for different $N = 77$ odd-odd isotones in the mass A $\sim$ 140 region. Understanding of these phenomena is one of the primary motivations in the present work through the investigation of structural evolution of the $N = 77$, ^{140}Eu ($Z = 63$) nucleus.

High-spin states of ^{140}Eu were previously studied by the heavy-ion fusion evaporation reaction by employing the recoil-isomer tagging as well as the conventional γ-ray spectroscopy techniques [4]. Based on these measurements, a total of 69 number of γ transitions were placed in the five band-like structures. The observed doublet structure was tentatively proposed to be chiral partners but experimental transitional probabilities viz. $B(M1)$ and $B(E2)$ values were not measured. In addition, one dipole cascade was identified without any connecting transition to the established bands. Our primary motivation in the present work is to explore the

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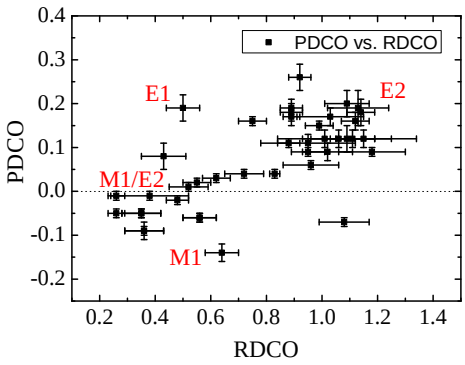

FIG. 1: Measured PDCO vs. RDCO plot for the γ transitions of ^{140}Eu. RDCO has been calculated by gating at pure $E2$ transitions.

chiral structure if exists in ^{140}Eu along with the detail spectroscopic study.

Excited states of ^{140}Eu was populated at the the Pelletron facility of IUAC, New Delhi by the fusion evaporation reaction ^{112}Cd(^{32}S, p3n) using beam energy of E_{Lab} = 145 MeV. Indian National Gamma Array (INGA) which consisted of sixteen Compton suppressed clover detectors, positioned at five different angles 148°, 123°, 90°, 57°, and 32° was used to detect the de-excited γ rays. The de-exciting γ-ray events were only recorded when at least two detectors had fired within a time window of 800 ns.

All the previously reported transitions have been observed and have been confirmed in the present experiment [4]. In the current experimental analysis level scheme of ^{140}Eu has been constructed above the 5^- (125 ms) isomer. In the earlier measurement [4], a cascade of $M1$ transitions having energies 152.6, 209.8, 275.5, 396.5, and 471.5 keV was reported, which was not connected with the established level scheme. In the present coincidence measurements, five new transitions 649.3, 785.8, 632.4 and 870.4 keV were found which connects this cascade to the level scheme. Because of the weak nature of these transitions, only the R(θ) measurements were possible. Thus, the parity of the suspended $M1/E2$ cascade has been assigned tentatively. In this present analysis, ten quadrupole bands and two dipole bands have been established. The proposed structure of ^{140}Eu has been established using the intensity, DCO ratio (R_{DCO}), ADO ratio and linear polarization (P) measurements [1]. The values of P against the R_{DCO} value for different γ transitions are shown in Fig. 1.

The level lifetime of the six levels of the positive parity side in ^{140}Eu were extracted using the DSAM technique. The Doppler broadened lineshapes at 32°, 90° and 148° were fitted simultaneously by the LINESHAPE packages [5]. The uncertainties on the lifetimes, derived from the χ^2-minimization analysis, do not include the systematic contribution of the stopping powers that was expected to be $\sim$ 10%.

From the present data a detailed level scheme could be established only up to $I \sim 20\hbar$. The level structure established from the present analysis, as performed till today, does not indicate the presence of any chiral doublet structure in the low spin domain ($I < 20\hbar$) of ^{140}Eu. Further data analysis is still in progress to extend the level scheme to the 4-quasiparticle bands which may be favorable for exhibiting the chiral structure in the ^{140}Eu nucleus.

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