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Nuclear shapes and symmetries seen through measurement of short lifetimes

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Nuclear shapes like triaxial, octopole and tetrahedral - with underlying symmetries and associated conserved quantities - have drawn considerable interest during recent years. Chiral symmetry (handedness) in triaxial nuclei manifests itself in two degenerate sets of energy levels. Their reduced transition probabilities B(M1) and B(E2) are the critical observables [1], obtainable from the measured lifetimes. Doppler shift attenuation method (DSAM) is a modern and sophisticated technique to measure lifetimes accurately in picoseconds. Signature splitting and signature inversion are yet another phenomena pointing towards different nuclear shapes. Recently we investigated 126I [2, 3] - a triaxial nucleus with changing shape and axis of rotation when excited to high angular momentum states - exhibiting both signature splitting and inversion, and possibly chirality.
We produced 126I through the reaction 124Sn(7Li, 5n)126I using 7Li beam at energy 50 MeV from the Pelletron accelerator at Inter University Accelerator Center, New Delhi, India. The experimental set-up consisted of 15 Compton suppressed HPGe clover detectors installed in INGA set-up [4]. We obtained lifetimes of many states [3] - ranging from 1.2 to 2.7 ps - by observing lineshape profile of the decaying γ-transition and peak fitting using the software by J. C. Wells [5]. A typical gated spectrum in the figure presents the right- and left-side Doppler shifted profiles of a γ-transition in the forward (32°) and backward (148°) detectors, respectively, compared to the Gaussian peak at the 90° detector.
We reported signature splitting and inversion in the negative parity yrast band of 126I [2]. Lifetime measurement using DSAM enabled us to establish changing triaxial shapes at the inversion point, i.e., at low and high spins [3]. We originally proposed chiral bands in 126I [2] based on roughly degenerate energy states, which is currently being investigated through lifetime measurement using DSAM. The initial B(E2) values 0.11, 0.04 and 0.05 (e2b2) for 17+, 18+ and 19+, respectively, indicate possible chiral nature [1].
In our ongoing work, we aim to study chirality in 128La - produced through 114Cd(19F, 5n)128La - by measuring lifetimes (DSAM) of the proposed chiral bands [6] by applying a stringent test on B(E2) [1].

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