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Lifetime measurement in Gd isotopes around N = 90

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Quantum shape phase transitions and shape coexistence in finite many body quantum systems, such as nuclei, are of contemporary interest [1]. The phenomenon of rapid shape changes as a function of nucleon number has been observed in the rare-earth region around N = 90. The N = 90 nuclei in Sm-Gd region are well known for the observation of quantum shape phase transition from spherical to well deformed rotor as well as coexistence of different shapes with very close lying minima. Empirical signatures for shape changes in a sequence of even-even nuclei are, e.g., a rapid change in the ratio $R_{4/2}$ = $E({4_1}^+)/E({2_1}^+)$ or a sudden rise in the E2 transition strength B(E2; ${2_1}^+ \longrightarrow {0_{gs}}^+$) [2,3]. Another signature for a QPT is the E0-transition strength ρ^2(E0). The coexistence of deformed shapes are manifested with the presence of multiple low lying 0^+ levels with one of the key signatures being the high E0 decay rates. In this context, the experimental identification of the low lying 0^+levels and the measurement of their lifetimes is very important.
Among the Gd and Sm nuclei, quantum shape phase transition has been proposed with observation of high E0 decay from the ${0_2}^+$ level in N = 88 ^{152}Gd [4]. In our recent measurement, similar signature in the ${0_3}^+$ level of N = 88 ^{150}Sm have been observed as the decay of level shows high E0 strengths [5]. Other than the Sm nuclei, the E0 strength is not known for the ${0_3}^+$ levels in any other nuclei in this mass region. Specifically, the ${0_3}^+$ level has already been observed in N = 90 Gd and the associated structure has been conjectured as the pairing isomer. However, there is no experimental data available on the lifetime measurement in this nucleus. In the present work, the level lifetime measurement of ${0_3}^+$ in ^{154}Gd (N=90) and other spin states such as ${2_1}^+$, ${4_1}^+$ in ^{152,154}Gd has been aimed using γ-γ fast timing technique.
The low lying excited states of ^{154}Gd were populated through two different reactions - one through the $\beta-$ decay of ground state of ^{154}Tb ($T_{1/2}$ ~ 21.5 hr.) produced using ^{154}Gd(p,n)^{154}Tb reaction with 12 MeV proton beam delivered from K-130 cyclotron at VECC, Kolkata. Proton induced reaction has been performed for the cleaner population of ${0_3}^+$ in ^{154}Gd (N=90) by restricting the population of high spin isomers in ^{154}Tb. The high spin states in ^{152,154}Gd has been populated through the $\beta-$ decay of higher lying isomers in Tb isotopes produced through neutron evaporation reaction using 40 MeV α beam from K-130 cyclotron on ^{nat}Eu target. The decaying gamma rays from excited states have been detected with VENTURE array [6], which consists of eight fast scintillator $CeBr_3$ detectors, coupled to two Compton supressed Clover HPGe detectors. The pulse processing has been done with NIM electronics and VME data acquisition with high resolution Mesytec ADCs.
The data from the present experiment has been analyzed using generalized centroid difference analysis for the measurements of sub-nanosecond lifetimes. The results from this measurement will be discussed in the light of observation of exotic quantum phenomena like shape phase transition and shape coexistence in nuclei around A~150.

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