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Uncertainties in Measuring the Lifetime of a Nuclear Excited State via $\gamma - \gamma$ Coincidences using NaI (Tl) Scintillators

Metrological difficulties in measurement of lifetimes of nuclear states have posed controversies in the quest to answer the fundamental question of whether lifetimes of nuclear states are invariable or not. Although several studies have suggested the possibility of slight variations of lifetimes depending on conditions of the nucleus [1, 2, 3], it is important to note that any claims of non-constancy of lifetimes as a consequence of deviation from the exponential decay curve can only be considered upon verification and accountability of stability and uncertainty of the devices used during the experiment [4]. Consequently, studying the uncertainties in lifetime measurement is a crucial step towards studying the possibility of variation of the lifetime of a nuclear-excited state when the nucleus is subjected to resonance conditions via multiple emission and reabsorption of gamma rays as suggested in [5]. We have, therefore, design a system to precisely measure the lifetime of the state via gamma-gamma coincidences using multiple fast scintillators. Measurement uncertainties were thoroughly studied using a pair of NaI (Tl) detectors on a simple bench-top setup. All possible sources of lifetime measurement uncertainties with their magnitudes are presented in the uncertainty budget. A measurement uncertainty of 0.661 % was observed indicating the suitability of the system for observing the variations of the lifetime that range from 1 % of the known value.

Keywords: nuclear state, lifetime of a nuclear state, uncertainty, resonance conditions, metrology

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