Angular Correlation and lifetime measurement in ^{150}Sm

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Introduction

The N=90 shape transition region has long been of interest due to the rapid evolution of structure that occurs in spanning the nuclei from N=88 to N=92. Nuclei with N≤88 have level schemes that resemble those expected for 'spherical' vibrational nuclei, whereas those for N≥92 resemble well-deformed prolate rotors [1]. The N=88 ^{150}Sm is one such nucleus which is known to lie at the transitional region in this mass region [2, 3]. Substantial number of theoretical and experimental studies exist in the literature focussing on the low lying structure of ^{150}Sm and its neighboring isotopes [4–6] but the spin-parity and level lifetime of the low lying states of this nucleus populated from β-decay of ^{150}Pm are not much studied. We have initiated the study on the low lying states of ^{150}Sm by performing experiment to study γ-γ coincidences and determine the β-endpoint energies corresponding to different β branches of ^{150}Pm→^{150}Sm decay [7, 8].

The $\gamma-\gamma$ angular correlation measurement is an effective method to make spin assignments for nuclear excited states and deduce multipolarities of γ transitions in nuclear decay spectroscopy. The observation of the directional correlation of two successively emitted nuclear radiations gives direct information of the angular momenta of the nuclear states involved and of the multipole character of the emitted radiation field. The angular correlation method is very useful for the determination of the relative amount of different angular-momentum components in mixed multipole transitions. On the other hand, measurement of lifetime and transitions moments for excited nuclear levels carries utmost importance in experimental nuclear physics as it provides direct insight into structure of a nucleus.

In the present work, the main objective is to determine the multipole character of several decaying transitions of ^{150}Sm by angular correlation technique and to measure the level lifetimes of the excited states from which the transition probailities can be found out. Preliminary analysis has been performed on $\gamma-\gamma$ correlation measurements and analysis on level lifetime has been started.

Experiment

^{150}Pm was produced by the reaction ^{150}Nd(p, n)^{150}Pm [9] which then, produces the excited states of ^{150}Sm, following β-decay. A beam energy of 8.5 MeV and a stack of three targets and two Al catchers were used for several irradiations. The 900 μg/cm^2 thick ^{150}Nd target (97% enriched) was prepared by electro-deposition on a 7.5 μm thick Al foil. The coincidence set-up consisted of VENUS (VECC array for NUclear Spectroscopy) array [10] with six n-type coaxial Compton Suppressed BGO shielded Clover HPGe detectors (at 30°, 90°, 180°, 260° and 310° w.r.t a detector taken as a reference of 0°) placed at a distance of 17.7 cm from the target position. An ancillary array of eight fast timing $CeBr_3$ detectors were coupled to the VENUS array in order to facilitate the lifetime measurement of the excited states of ^{150}Sm [11]. For the collection of γ-γ coincidence data, a MASTER logic of ($M_\gamma \geq 2$ within six CLOVER).OR.($M_\gamma \geq 2$ within eight $CeBr_3$) was established.

The probability of detecting γ_2 at an angle θ w.r.t γ_1 is given by the angular correlation function which is written as a sum of legendre polynomials, P_k, by

$$W(\theta)=1 + a_2P_2(\cos\theta) + a_4P_4(\cos\theta)$$

a_2, a_4 depends on the spin of the levels and the multipolarity of the transitions and can be calculated theoretically or can be determined as free parameters in a fit of experimental data. Comparision of the experimental (a_2, a_4) values with the theoretical results gives the mixing ratio (δ) of the corresponding transitions.

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FIG. 1: Set-up used for angular correlation measurement for ^{150}Sm γ rays.

Data Analysis and Results

The obtained data has been sorted using the LAMPS software to construct the RADWARE compatible γ-γ asymmetric matrices with the 0° detector along the x-axis and the other angle detectors (viz. 310°, 260°, 180°, 90° and 30°) along the y-axis. Fig. 2 shows the angular correlation of 832; 1213 and 1767 keV transitions gating on 334 and 712 keV respectively, corresponding to ^{150}Sm. The 832 keV γ-ray was previously known as E2 but the spin and parity corresponding to the level from which 1213 keV decays was assigned as (1^-) [12]. Similarly, fig. 2(c) represents the angular distribution of 1767 keV transition which decays from a level with E_x=2812.9 keV with Jπ=$(1^-,2)$ [12]. We have calculated the (a_2, a_4) values for some of the cascades in ^{150}Sm which can also be calculated theoretically for different mixing ratios comparing with which we can determine the mixing of the concerned γ transition with other multipoles. Moreover, for the lifetime measurement with Generalized Centroid Difference technique, the prompt calibration curve has been generated from the data taken with standard sources. The centroid differences corresponding to different excited levels are being determined to measure the lifetimes.

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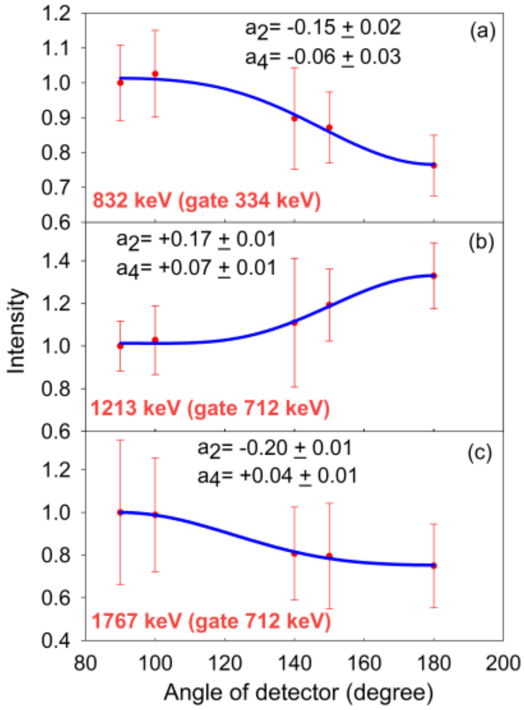

FIG. 2: Angular correlation of (a) 832-334 (b) 1213-712 and (c) 1767-712 keV cascades.

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