Linear Polarization and Mixing Ratio Measurements

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Introduction

The linear polarization measurements are important for determination of mixing ratio and electric/magnetic nature of the gamma rays. The linear polarization measurements are important for unambiguous assignment of the spin and parity of nuclear states [1].

The segmented HPGe Clover detectors of Indian National Gamma Array (INGA) [2] provide an opportunity to measure the polarization of γ-rays [3].

The paper presents the results of polarization sensitivity of Clover detectors of INGA and also the results of linear polarization and mixing ratio of γ-rays of interests.

Experimental Details

Excited states of $^{134-136}$Ce nuclei were populated via ^{124}Sn(^{16}O,xn) fusion evaporation reaction at 90 MeV beam energy. The experiment was carried out using the 15UD Pelletron Accelerator facility at Inter-University Accelerator Center (IUAC), New Delhi.

Results and Discussion

The linear polarization P(θ) depends on polarization asymmetry (Δ) and polarization sensitivity (Q) as follows [1]:

$$P(\theta) = \frac{\Delta}{Q}$$

The polarization asymmetry of a Compton scattered photon has been defined as

$$\Delta = \frac{a(E_\gamma)\cdot N_\perp - N_{II}}{a(E_\gamma)\cdot N_\perp + N_{II}}$$

where $N_\perp$ and N_{II} are the intensities of the full energy peaks measured from the perpendicular and parallel combination of crystals of clover detector and $a(E_\gamma)$ is

$$a(E_\gamma) = \frac{N_{II}(unpolarized)}{N_\perp(unpolarized)}$$

The linear polarization P(θ) is determined using the Klein-Nishina formula [4,5] in which the angular distribution coefficients a_2 and a_4 were used for ^{134}Ce, ^{135}Ce and ^{136}Ce [6-8]. The polarization sensitivity Q is fitted a linear function of energy [Fig. 1] using the following relation [1]:

$$Q = Q_0 \cdot (D + C \times E_\gamma)$$

where Q_0 represents the polarization sensitivity of an ideal Compton polarimeter and is defined as:

$$Q_0 = \frac{1+\alpha}{1+\alpha+\alpha^2}$$

where $\alpha = E_\gamma(keV)/511$.

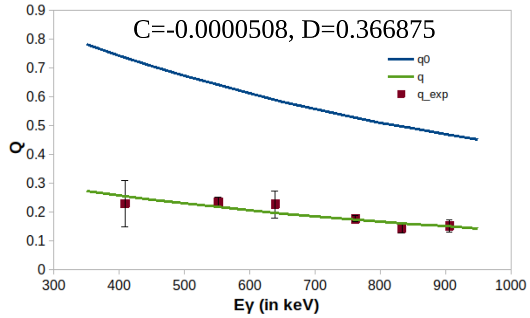

Fig. 1: Plot of polarization sensitivity Q and Q_0 vs E_γ.

Experimental values of P(θ), Δ and Q are determined for the γ-rays of interest [Table 1].

Nucleus	E_γ (keV)	P(θ)	Δ	Q
^{134}Ce	409	0.42(18)	0.098(6)	0.23(8)
^{136}Ce	552	0.27(3)	0.062(2)	0.23(2)
^{134}Ce	639	0.42(11)	0.095(5)	0.22(4)
^{136}Ce	762	0.37(3)	0.068(2)	0.19(1)
^{135}Ce	833	0.72(10)	0.103(3)	0.14(2)
^{135}Ce	906	0.69(12)	0.105(4)	0.15(2)

Table 1: Present experimental Δ, P(θ) and Q. The a_2 and a_4 taken from Ref [6-8].

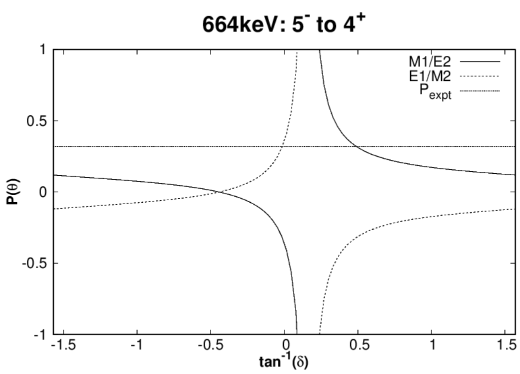

Fig. 2: Calculated polarization $P_{cal}(\theta)$ for the 664 keV (5^- to 4^+) in ^{136}Ce plotted as a function of arctan(δ) assuming E1/M2 and M1/E2 multipolarities with the experimental polar ization $P_{exp}(\theta)$.

In earlier analysis 664keV transition from ^{136}Ce was reported to have Δ=0.054(5) [9]. With the help of polarization sensitivity Q from the above analysis, the linear polarization $P_{exp}(\theta)$ is 0.319(16).

The calculated value of polarization $P_{calc}(\theta)$ is plotted as a function arctan(δ) by assuming E1/M2 or M1/E2 multipolarities for 664keV transition (5^- to 4^+) using the expressions as described in Ref. [5,10]. The experimental value and calculated curve intercepts at low |δ|~0.013. This suggests the pure E1 nature of 664keV γ-rays. There is also an intercept at high δ value which is ruled out by the angular distribution results [8].

Data analysis is under progress further details will be provided during the presentation at Symposium.

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