Polarization Measurements using INGA

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Introduction

Linear polarization distinguishes the electric and magnetic nature of a gamma ray. The linear polarization of gamma rays can be investigated from the observed asymmetry of the Compton scattering. Electric transitions result in a preferential scattering along the perpendicular direction, while the magnetic transitions result in a preferential scattering along the parallel direction. Hence, the Clover detector can be used as a polarimeter. Each crystal of a clover acts as a scatterer and the two adjacent crystals as absorbers. The motivation of the present investigation was to compare the polarization measurements undertaken with INGA array with already established polarization results and to extend these measurements to other nuclei.

The nuclei in mass $A \sim 150$ region have drawn considerable attention, both experimentally and theoretically due to their proximity to the $N = 82$ and $Z = 64$ shell closures. The generation of angular momentum in these nuclei has been a subject of interest for a long time. The low-lying region of the excitation spectra for these nuclei show irregular and complex patterns, typical of near-spherical nuclei and are dominated by single-particle and multi-particle excitations. The coupling of an $h_{11/2}$ proton to the 2^+, 4^+ and 3^- excitations of the neighboring even-even core results in an irregular parity sequence. Hence, the spin-parity assignments are crucial and have to be undertaken using both the observed angular co-relations and linear polarization measurements. In the present paper, we report our polarization measurements for ^{146}Gd, which have been compared with measurements of Wiel *et al.*, which were performed using a five-detector Compton polarimeter. We also extend these measurements to the neighboring odd-even ^{145}Tb.

Experimental Details

Excited states in ^{146}Gd were populated by the ^{115}In(^{34}S,$1p2n$) reaction at a beam energy

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of 140 MeV. An isotopically-enriched ^{115}In target of $\sim$ 1.29 mg/cm^2 thickness with a $\sim$ 7.14 mg/cm^2 Au backing was used. The ^{34}S beam was provided by the 15UD Pelletron facility at the Inter University Accelerator Centre (IUAC), New Delhi. The γ-rays were detected with INGA [*the Indian National Gamma Array*], comprised of 8 Compton-suppressed Clover detectors. These detectors were placed at 80° and 140° with respect to the beam direction. A total of about 220 million two- or higher-fold γ-γ coincidence events were recorded in the experiment.

Data analysis and Results

^{145,146}Tb [1], ^{146}Gd have been strongly populated in this reaction. Asymmetry was determined from a matrix constructed with one axis corresponding to perpendicular or parallel scattered events in 80° detectors and other axis corresponding to total energy in the other detectors. The gate is then set on the total energy and the asymmetry between the parallel and perpendicular scattering is determined.

The linear polarization was obtained using the relation between the polarization sensitivity $Q(E_\gamma)$ [3] and the observed asymmetry. Fig. 1 illustrates the comparison of the present polarization measurements with the earlier reported work of Wiel *et al.*. These measurements are in excellent agreement with the theoretical predictions.

These measurements were then extended to the neighboring ^{145}Tb. In the earlier work by Zheng and co-workers [4], the spin-parity measurements were based on the observed angular-distribution, which is insensitive to the electro-magnetic nature of the transitions. The preliminary results indicate a contradiction with the earlier reported values. Representtaive results for a few of the transitions belonging to ^{145}Tb are also included in Fig. 1. The preliminary results indicate a contradiction with the earlier reported values. The present measurements indicate that the 475 keV transition which was earlier assigned as M1, is an electric ($DeltaJ = 1$) transition. Spin and parity of the levels are being assigned consistently from both the DCO and linear

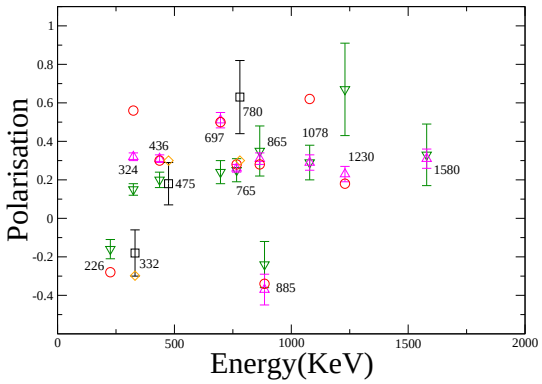

FIG. 1: Comparison of present Polarization measurements (inverted triangles) with the earlier work (triangles) in ^{146}Gd. The squares represent the polarization measurements in ^{145}Tb. The theoretical values are indicated by "diamonds" and "circles" in these nuclei.

polarization measurements and will compare with the theoretical values.

The present measurements has necessited changes in the parity assignments The comparison of the present polarization measurements with the reported values, provides us with a figure-of-merit for such measurements being undertaken using INGA.

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