Angular Correlation measurement around Z = 64

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Introduction

The measurement of γ-γ angular correlation of a suitable γ-γ cascade is one of the very important techniques that are used in the experimental nuclear structure study using Gamma spectroscopy. The unperturbed measurement is used for the determination of multipolarities and their mixing ratios for the associated γ-transitions [1] while the perturbed angular correlation(PAC) measurement yields the transition moments of the nucleus [2] in the intermediate state present in the γ-γ cascade. In a PAC measurement, the transition moment of a nucleus interacts with the applied electric or magnetic field when the angular correlation is attenuated by a factor, called attenuation or perturbation function. The PAC experiment is performed in two different modes, viz., Time Differential Perturbed Angular Correlation (TDPAC) and Integral Perturbed Angular Correlation (IPAC) techniques.

With the aim of studying the unperturbed and perturbed angular correlation, an angular correlation set up has been developed at VECC, Kolkata. Following the said development, the unperturbed angular correlations have been measured in the nuclei which are close to the Z = 64 subshell closure of proton, viz.,^{152}Gd, ^{152}Sm and ^{146}Eu. The former two nuclei with N = 88 and N = 90 lie in the deformed region and shows the well deformed rotational levels [3]. The latter one with N = 83 lies near the shell closure of N = 82 and shows the single particle configurations as per the shell model calculations [4]. The evolution of nuclear structure at these two extremes can be explored with the measurement of quadrupole moments in these nuclei. Hence the perturbed angular correlation measurements have been planned with IPAC and TDPAC techniques.

Experimental Setup and Results:

The angular correlation table, as shown in Fig. 1, has been developed at VECC which can house three $LaBr_3$(Ce)/$CeBr_3$ detectors. Two of these detectors are fixed at an angle of 90° with respect to each other. The third detector can rotate at different angles in the 360° plane on the angular correlation table. The relative angles can be adjusted with an accuracy of 1° and the target-detector distance can be varied up to a distance of 20 cm. The source holder has been fabricated to house sources of different configurations and can be adjusted vertically. In the present work, the angular correlation has been measured with two $LaBr_3$(Ce) detectors for the 1172-1332 keV cascade of ^{60}Ni, 121-244 keV cascade of ^{152}Sm, 344-778 keV and 344-411 keV cascades of ^{152}Gd. The first cascade has been obtained from the β-decay of ^{60}Co source and the latter cascades have been obtained from the β^+/EC and β^- decays of ^{152}Eu source respectively. The angular correlation measurements has also been performed in two different cascades of ^{146}Eu, obtained from the EC-decay of ^{146}Gd which was produced by ^{144}Sm(α,2n)^{146}Gd reaction with 32 MeV α-beam from K = 130 cyclotron at VECC, Kolkata. In case of ^{146}Eu experiment the residues of Gd nuclei were collected in an aluminium catcher foil and were radiochemically separated by using co-precipitation technique.

Data Analysis and Results

The angular correlation between two γ-rays in cascade can be calculated with a knowledge of the F-coefficents[3] and can be expressed as a function of angle between the two detectors as

$$W(\theta) = A_0 + A_2P_2(cos\theta) + A_4P_4(cos\theta) \quad (1)$$

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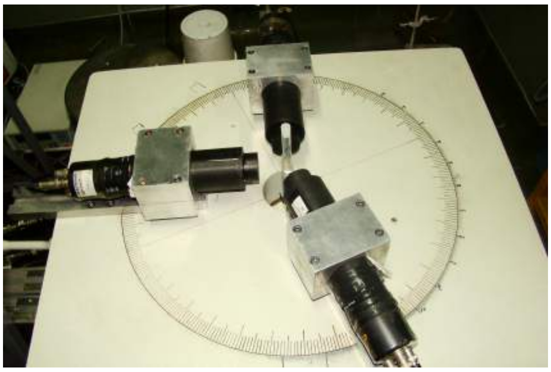

FIG. 1: Angular correlation table fabricated at VECC, Kolkata

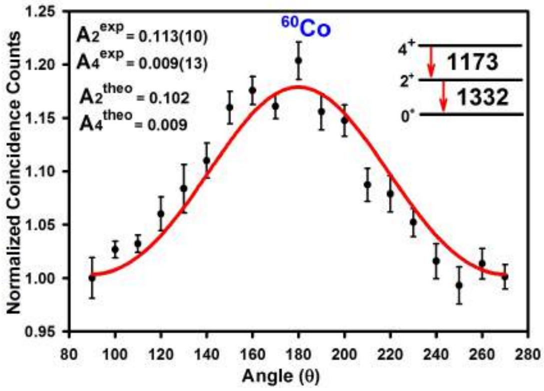

FIG. 2: Angular correlation plot for ^{60}Co nucleus

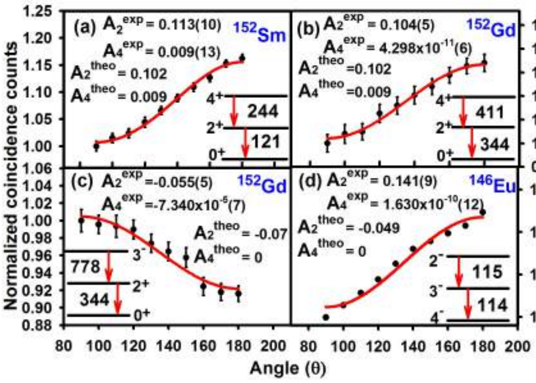

FIG. 3: Angular correlation plots for different cascades

where the A_0 and A_2 are known as the angular correlation coefficients that depend on the multipolarity of the transitions in the cascading transitions, the angular momentum of the nuclear levels and the mixing ratio associated with the transitions. $W(\theta)$ can be experimentally obtained by measuring the efficiency corrected coincidence events observed at a particular angle. The geometry of the source and detectors are very important parameters in order to obtain the angular correlation coefficients with substantial accuracy. In the present work, this has been established with the measurement of the angular correlation of the 1173-1332 keV cascade obtained from the β^- decay of ^{60}Co. This experimental data points have been shown in Fig.2 and are fitted with the eqn.1. The obtained angular correlation coefficient, as indicated within the figure, matches well with the theoretical values and indicates the correct geometry of the setup. On successful testing of the setup, the angular correlations have been measured in ^{152}Gd, ^{152}Sm and ^{146}Eu for different cascades as has been shown in Fig.3. The angular correlation coefficients obtained for the 121-244 keV cascade of ^{152}Sm and the 344-411 keV cascade of ^{152}Gd match with the theoretical coefficients establishing the 0-2-4 angular momentum sequence. However, the A2 value obtained for the 344-778 keV cascade of ^{152}Gd indicates an M2 mixing in the 778 keV transition which was earlier assigned as E1. Similarly, the 114-115 keV cascade of ^{146}Eu indicates a mixing in the 115 keV cascade. The detailed analysis is in progress.

Acknowledgments

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