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Linear polarization measurement on gamma rays from non-oriented nuclear states

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Gamma ray spectroscopy is a powerful tool in nuclear structure, but the interpretation of the intrinsic properties of the nucleus becomes complex if the parity of the emitted radiation is not known. This study aimed at developing a technique to measure linear polarization of ɣ rays emitted
from non-oriented nuclear states for the clover detectors of the iThemba LABS AFRODITE and GAMKA arrays. Orientation was created by gating on a ɣ ray detected in one clover detector while observing another ɣ ray detected in coincidence in another detector. Having being well known for
their high efficiency in detecting ɣ rays, the clover detectors used in this study comprise 4 Ge crystals which were used as Compton polarimeter, which allows us to measure linear polarization. A focus was made on studying the Compton scattering of ɣ rays across the 4 Ge crystals in which the Klein-Nishina equation was utilised for the two experimental set-ups to measure the polarization anisotropy. Theoretical curves for all observed rays emitted from the beta-decay of 152 Eu were derived and compared with the measured polarization anisotropy, Ap to deduce the polarization sensitivity, Q(ɣ). Furthermore, the degree of linear polarization was determined experimentally for the ɣ rays observed in 196Hg following the beta-decay of 196Tl using the deduced polarization sensitivity for the AFRODITE array. The technique has also been applied
for the upgraded GAMKA array. The polarization sensitivity for the GAMKA array was determined using experimental data with Eu source by measuring the linear polarization anisotropy and comparing it with the theoretical curves for linear polarization for the well-known pure transitions.
The derived linear polarization sensitivity Q was then used to determine mixing ratios of observed mixed transitions. In addition, the angular correlation coefficients for both pure and mixed transition have been measured and compared with the theoretical coefficients. Lastly, final values for the mixing ratios for M1+E2 and E0+M1+E2 transitions have been determined by combining angular correlation and linear polarization results for all observed ɣ ray cascades detected with the GAMKA
array and with Eu source. The deduced polarization sensitivity can be used in future experiments that intend to measure ɣ rays whose parities as well as mixing ratios are not known.

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