偏光ガンマ線の弾性散乱の検証
Validating Elastic Scattering of Polarized Gamma-Rays

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Abstract

An elastic scattering experiment has been performed using a 100% linearly polarized γ-rays generated by laser Compton backscattering at Duke University, NC, USA. Photons of an energy of 2 MeV elastically scattered off a uranium target were measured with high-purity Ge detectors. The results are used in the simulation study to improve the sensitivity of identifying isotopes by nuclear resonance fluorescence. Validation of the elastic scattering cross section of polarized gamma-rays is reported.

Keywords: Elastic scattering; Linearly polarized gamma-rays; U target.

1. Introduction

Elastic scattering of γ-rays is a fundamental process involving the coherent sum of many sub-processes that occur when the incident photons interact with the individual constitutes of the atom. Above 1 MeV and below the energy of the giant dipole resonance of the atomic nucleus, three processes are dominant. These processes are Rayleigh, nuclear Thomson, and Delbrück scattering. Many theoretical calculations and experimental investigations had been performed to evaluate the cross section of the elastic scattering. However, the lack of polarized photon sources limited those experimental works to the unpolarized photon sources. In this work, we report the first measurement of the elastic scattering of a 100% linearly polarized γ-rays generated by the laser Compton backscattering source.

2. Experimental

Uranium disks of 2.5 cm diameter and 0.5 cm total thickness were irradiated by a quasi-monochromatic linearly polarized γ-ray beam of a central energy of 2.04 MeV and a width of approximately 80 keV at the HIγS facility, Durham, NC, USA. Photons scattered at (θ,φ) of (90°,0°) and (90°,90°) were detected by two high-purity Ge detectors.

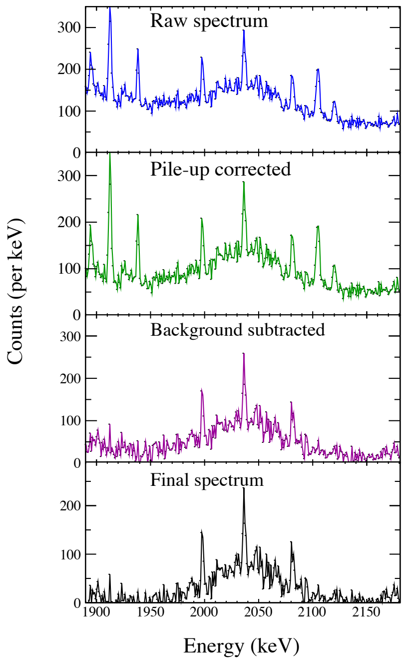

Fig. 1: Spectral analysis sequence of the measured data with the detector located at (90°,90°). The 3 peaks in the final spectrum are deexitations of ^{238}U nucleus.

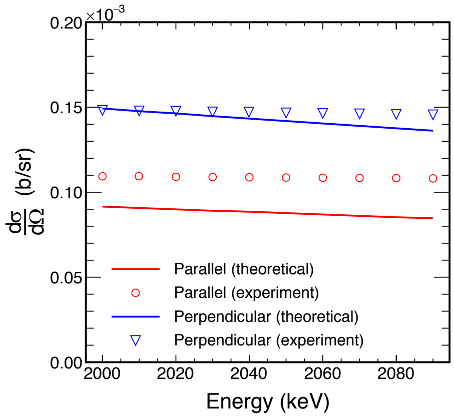

Fig. 2: Experimental and theoretical elastic scattering diffremtial cross sections for U at 90°.

3. Results・Conclusion

Fig. 1 shows the measured spectra of the elastically scattered photons at (90°,90°) and demonstrates the background subtraction and relevant corrections. Fig. 2 shows the differential cross section measured in the parallel and perpendicular directions to the polarization of the incident beam. Theoretical calculations, obtained from the literature, are also depicted in the figure. The difference between the measured and calculated cross sections is approximately 10% for the parallel direction and 5% in the perpendicular direction. Nevertheless, the measured cross sections exhibit smaller dependence on the energy than those obtained in the calculated cross sections.