Compton scattering

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I. INTRODUCTION

II. THEORY

II.1. Inelastic scattering of photon

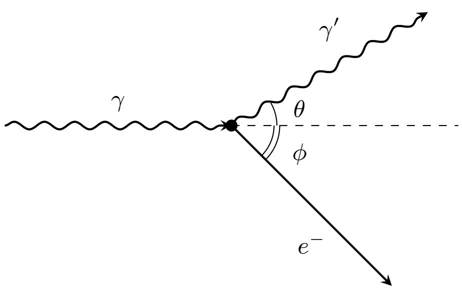

FIG. 1. Compton scattering of a photon by an electron. γ and γ' are the incident and scattered photons. e^- is the recoil electron initially at rest. θ and ϕ are the scattering and recoil angles, respectively.

Following relativistic kinematics, we treat photons as massless particles of energy $E_\gamma = h\nu$, where h is the Planck constant and ν is the photon frequency. The energy of an electron is given by $E_e = \sqrt{m_e^2c^4 + p_e^2c^2}$, where m_e is the electron rest mass, p_e is the electron momentum, and c is the speed of light. By conservation of energy E and momentum $\vec{p}$, we have

$$E_\gamma + E_e = E'_\gamma + E'_e, \tag{1}$$
$$\vec{p}_\gamma + \vec{p}_e = \vec{p}'_\gamma + \vec{p}'_e, \tag{2}$$

where the prime denotes the final state. For simplicity, we take the initial electron energy as $E_e = m_ec^2$, that is the particle is initially at rest. Solving Equations (1) and (2), we obtain the energy of the scattered photon as

$$E'_\gamma = \frac{E_\gamma}{1 + \frac{E_\gamma}{m_ec^2}(1-\cos\theta)}, \tag{3}$$

with θ being the scattering angle, i.e. the angle between the initial and final photon momenta. The kinetic energy of the recoil electron is then approximated as $E'_e = E_\gamma - E'_\gamma$. The scattering scheme is illustrated in Figure 1.

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θ [deg]	Counting Time [s]	Total Time [s]	Collection Date [YYYY-MM-DD]
0	964	1012	2025-03-04
30	1194	1224	2025-03-04
60	1619	1658	2025-03-04
90	1856	1900	2025-03-04
120	1706	1736	2025-03-04
15	1354	1522	2025-03-06
45	1333	1455	2025-03-06
75	1954	2058	2025-03-06
105	1645	1727	2025-03-06
135	1341	1431	2025-03-06

TABLE I.

II.2. Differential cross section

In the classical regime, the cross section of Compton scattering can be approximated by the Thomson formula for elastic collisions [1], given by

$$\frac{d\sigma}{d\Omega} = \left(\frac{e^2}{4\pi\epsilon_0 m_e c^2}\right)\frac{1+\cos^2\theta}{2}, \tag{4}$$

with e being the electron charge and ϵ_0 the vacuum permittivity.

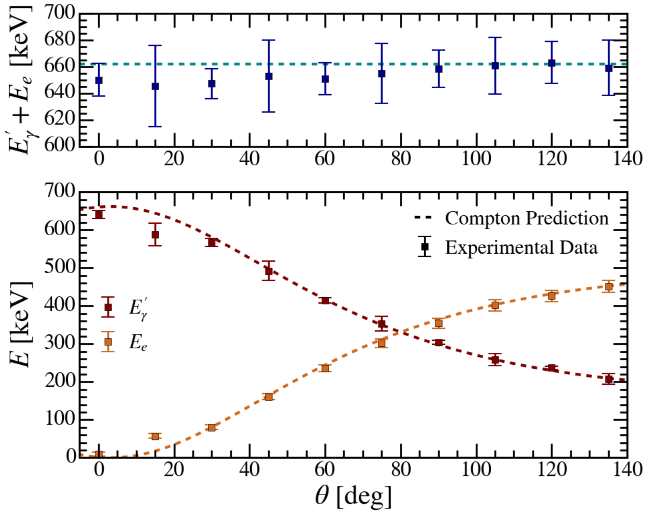

FIG. 2.

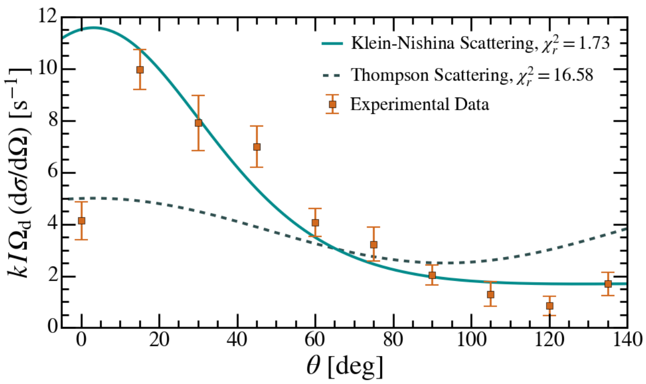

FIG. 3.

II.3. Total cross section & Attenuation

III. EXPERIMENT SETUP

III.1. Apparatus

III.2. Data Collection

IV. ANALYSIS & RESULTS

IV.1. Energy-angle dependency

IV.2. Scattering rate

V. DISCUSSION & CONCLUSION

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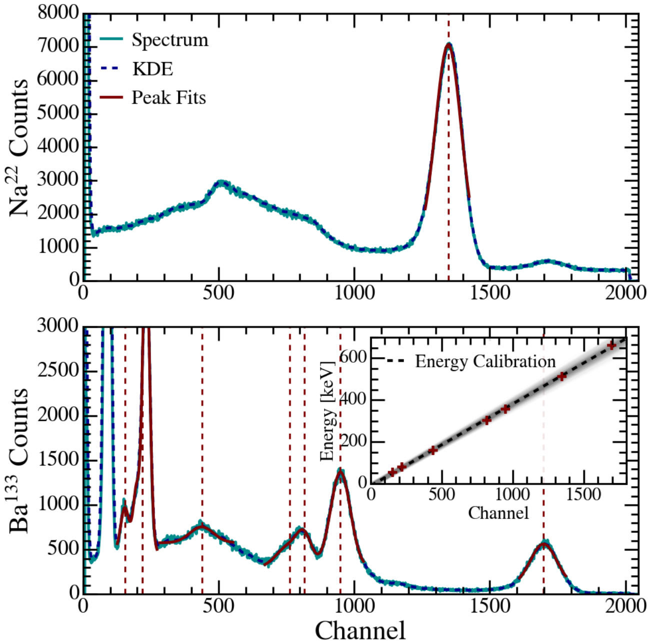
[1] J. D. Jackson, *Classical electrodynamics; 2nd ed.* (Wiley, New York, NY, 1975).

Appendix A: Energy Calibration



Spectrum
KDE
Peak Fits
Na^{22} Counts
Ba^{133} Counts
Channel
Energy Calibration
Energy [keV]

FIG. 4.