Compton Scattering

Unit: Quantum and Particle Physics

NGSS Standards/MA Curriculum Frameworks (2016): N/A

AP® Physics 2 Learning Objectives/Essential Knowledge (2024): 15.6.A, 15.6.A.1, 15.6.A.2, 15.6.A.2.i, 15.6.A.2.ii, 15.6.A.3

Mastery Objective(s): (Students will be able to…)

- Describe the interaction between photons and matter using Compton scattering.

Success Criteria:

- Descriptions & explanations are accurate and account for observed behavior.

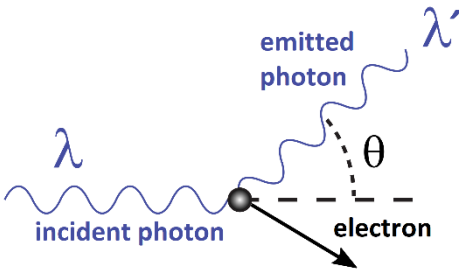
Language Objectives:

- Explain the important features of each model of the atom.

Tier 2 Vocabulary: scattering

Notes:

In 1923, American physicist Arthur Compton performed an experiment in which a photon collided with an electron. The collision caused a transfer of momentum and energy to the electron, which therefore caused the photon to emerge with less momentum and less energy (and therefore a different frequency and wavelength).



This experiment proved that photons exhibit particle behavior and cannot be considered to be only waves.

Applying the equations:

$$E = hf \quad \text{and} \quad \lambda = \frac{h}{p} = \frac{h}{m_e c}$$

gives the following equation:

$$\Delta\lambda = \frac{h}{m_e c}(1 - \cos\theta)$$

where:

- $\Delta\lambda$ = change in wavelength between the incident photon and the emitted photon
- h = Planck's constant = 6.63×10^{-34} J·s
- m_e = mass of an electron = 9.11×10^{-31} kg
- c = speed of light = $3.00 \times 10^{8} \frac{\text{m}}{\text{s}}$
- θ = angle of emitted photon relative to direction of incident photon