Compton Scattering

**Object:** To verify the Compton scattering equation by measuring the energies of scattered gamma photons at different scattering angles and as a result determine the mass of the electron.

**Theory:** When a photon collides with an electron, it is scattered and loses some of its energy to the electron. After scattering, the photon will always have less energy than before scattering and therefore always have a lower frequency. A photon that is scattered at a large angle will lose more energy than a photon that is scattered at a small angle. This phenomenon is called Compton scattering and it is easily explained by the quantum theory of light. If a photon is assumed to be a particle, conservation of energy and momentum can be applied to the collision of the photon with an electron.



From conservation of energy: hv + mc2 = hv' + √(m2c4 + p2c2)

From conservation of momentum: hv/c = (hv'/c)(cosθ) + p(cosϕ) and 0 = (hv'/c)(sinθ) - p(sinϕ)

Converting from frequency to energy (v=E/h) and manipulating these equations algebraically yields 1/E' = 1/E +(1/mc2)(1 - cosθ)

*List of equations:*

1/E' = 1/E + (1/mc2)(1 - cosθ)

E= hv

*List of variables*

h = Plank`s constant

v = frequency of gamma ray

v' = frequency of scattered gamma ray

E = energy of gamma ray

E' = energy of scattered gamma ray

m = mass of electron

c = speed of light

θ = scattering angle

**Experiment:**



Before measurements could be taken, the equipment had to be calibrated. 3 sources were measured whose energy peak channels were known. This allowed conversion between channel number and energy for subsequent measurements. Next, we determined the position that the trolly should be placed in for maximum beam intensity. This position coincided with a scattering angle of 0 degrees. Next we determined the energy peaks for each scattering angle from 90 degrees to 0 degrees in 10 degree steps. The energy peak is the energy that most of the incoming photons were measured at.

**Analysis:**

Clearly, our data agrees with the relationship predicted by Compton's equation. It is linear with a reasonable slope. From the equation, 0.002 keV-1 = 1/mc2, so m = 0.5 MeV/c2

error in slope = δs = max fit slope - best fit slope = 0.002 - 0.0017 = 0.0003 keV-1

error in electron mass = δm= (δs)(c2)(m2) = 0.075 MeV/c2

Our value of 0.500 +/- 0.075 MeV/c2 for the mass of an electron agrees with the accepted value of 0.511 MeV/c2 within error.

The incident gamma ray energy, E, is predicted to be 1/b where b is the y intercept of the graph. From the graph, E = 0.625 MeV. This is reasonably close to the accepted value.

**Discussion:** Our data agreed with the relationship predicted by theory. We obtained a value of 0.500 +/- 0.075 MeV/c2 for the mass of an electron. The main source of error was stray radiation from other parts of the building.

**Conclusion:** Our results suggest that Compton`s equation is correct. The quantization of light into photons does well to explain why the wavelength of light increases after being scattered by an electron.

**Summary:** In this experiment we verified the relationship predicted by theory that in the wavelength of a scattered photon will always be longer than before it was scattered. We did this by measuring the energies of photons at different scattering angles and verifying that these energies were indeed those predicted by theory.