In the photoelectric effect, an electron absorbes a photon - the photon is utterly destroyed, it's energy and momentum passed onto the electron.

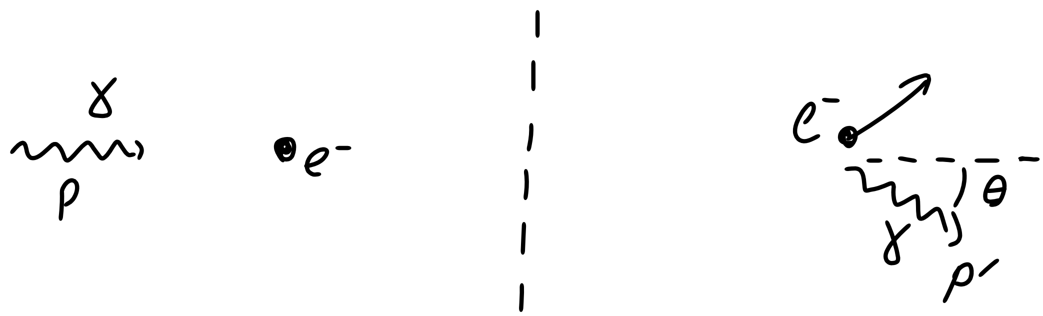
Can a free electron (as opposed to one bound in a metal) absorb a photon?

-> Clicker question

A: this process cannot conserve energy. Free electrons do not absorb photons.
So what happens when a photon is incident on a free electron? A: Compton scattering.

The Compton effect (scattering)

The details of the derivation are in Tutotorial 7. Let's review the set-up. The electron is initially motionless and the photon approaches in the direction of the x-axis. After the collision, the photon is an angle theta away from the a-axis and the electron is moving with some recoil velocity



From conservation of momentum, the momentum of the electron after is

$$p_x = p - \cos\theta \, p' \qquad p_y = \sin\theta \, p' \qquad E^2 = (pc)^2 + (mc^2)^2$$

so conservation of energy says that

$$pc + mc^2 = p'c + \sqrt{(p - \cos\theta \, p')^2 + (\sin\theta \, p')^2 + (mc^2)^2}$$

Isolate the square root, square both sides, don't make any mistakes and you will get

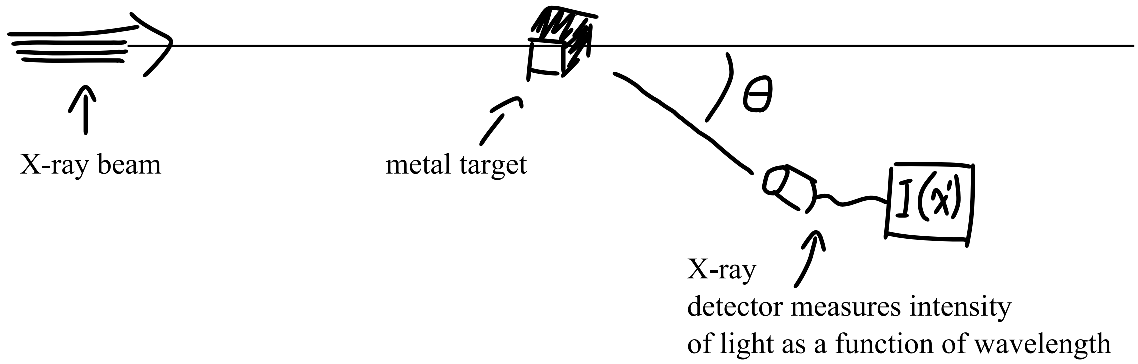
$$\frac{1}{p'} - \frac{1}{p} = \frac{1}{mc}(1 - \cos\theta)$$

$$p = \frac{E}{c} = \frac{hf}{c} = \frac{h(c/\lambda)}{c} = \frac{h}{\lambda}$$

$$\therefore \quad \lambda' - \lambda = \frac{h}{mc}(1 - \cos\theta)$$

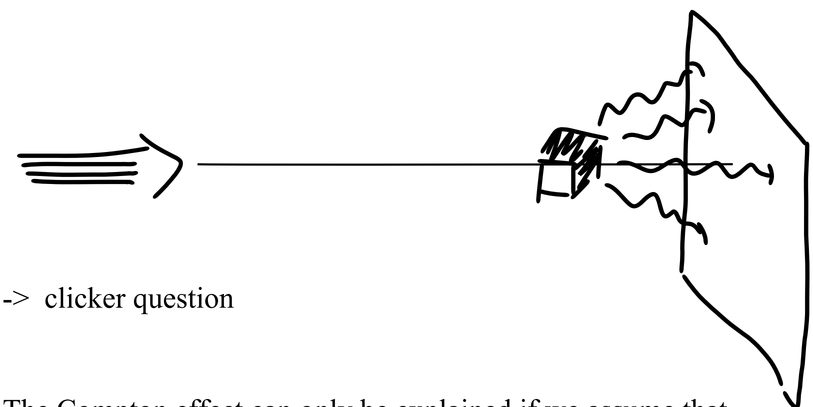
this combination (h/mc) is known as the Compton radius

What would an actual Compton effect experiment look like?



-> clicker question

This can be reconstructed into a picture, as if you just put a photoplate and detected colors of x-rays:

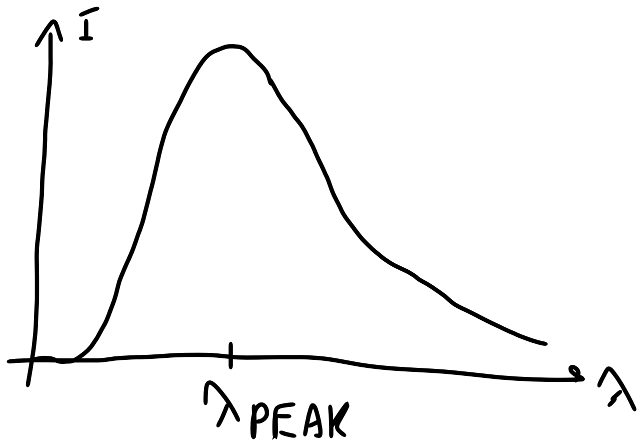


-> clicker question

The Compton effect can only be explained if we assume that light behaves like a particle. Compton got a Nobel prize for his discovery.

Black body radiation

A hot object next to some empty space will try to reach thermal equilibrium with that empty space.
To do so, it will try to fill the space with a thermal gas of photon, which we call black body radiation.
-> clicker question
It's spectrum looks like this



$$\lambda_{PEAK} = \frac{2,9\ 10^{-6}\ nm\ K}{T}$$

WIEN'S LAW