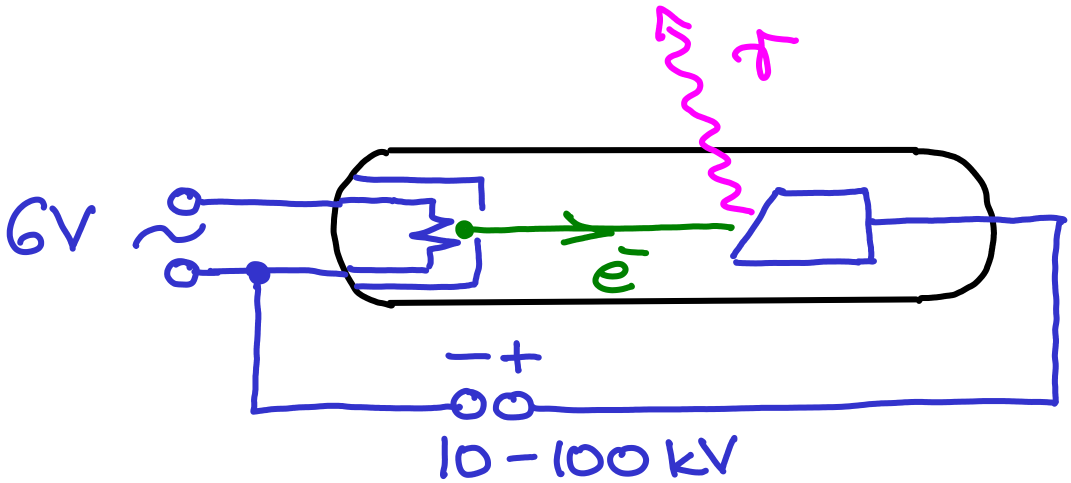
X-rays

Wilhelm Conrad Röntgen, 1895
(First Nobel Prize, 1901)



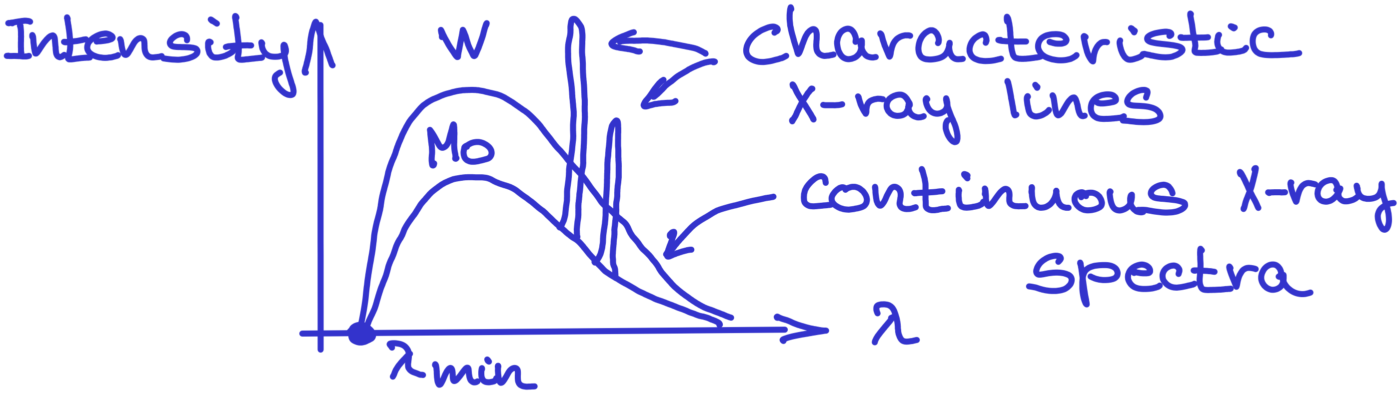
$\bar{e}$-side : $E_i - E_f = hf$: γ-side

$$eV_0 = hf_{max} = \frac{hc}{\lambda_{min}}$$

$$\boxed{\lambda_{min} = \frac{hc}{eV_0}}$$ Duane-Hunt rule

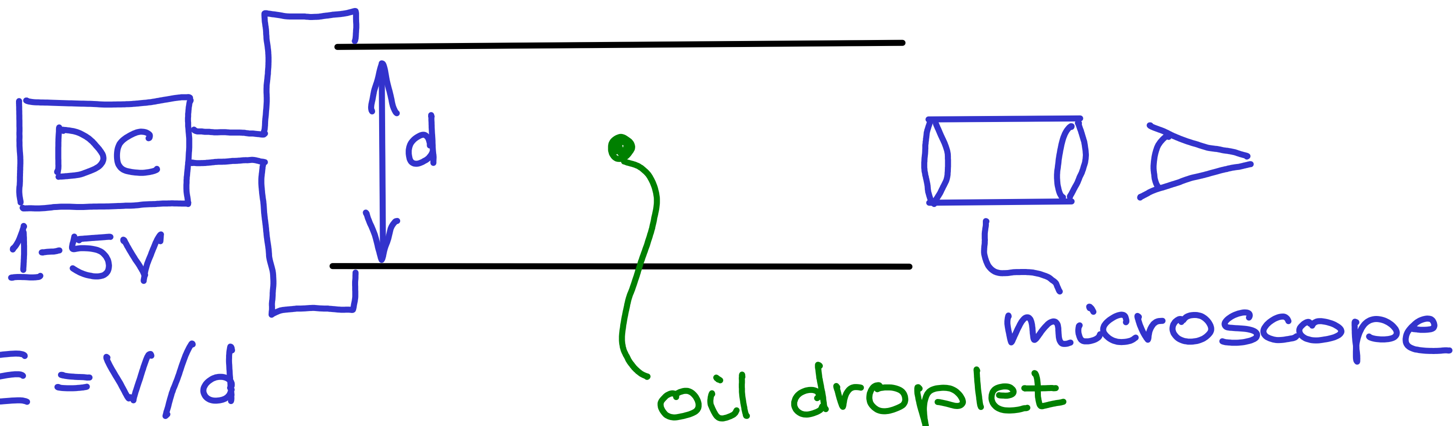
Photoelectric effect reversed

Q: Where is ϕ? A: $\phi \ll eV_0$.



Electron charge

Robert A. Millikan, 1907
(Nobel Prize, 1923)



$E = V/d$

floating: $\uparrow qE$, $\downarrow mg$ $\quad mg = qE \Rightarrow q = \frac{mg}{E}$

All the measured droplet charges were multiples of a certain charge:

$$e = 1.602 \cdot 10^{-19}\ C$$

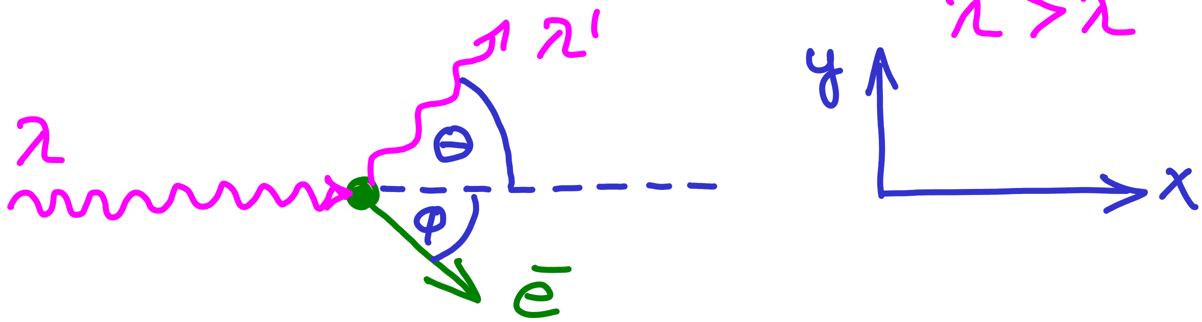
Using the charge density $\frac{e}{m}$ by Thomson:

$$m = 9.11 \cdot 10^{-31}\ kg$$

Compton - effect

Arthur Holly Compton

(Nobel Prize, 1927)



The photon elastically scatters on the originally resting electron.

$$hf + m_e c^2 = hf' + \left[(m_e c^2)^2 + p_e^2 c^2\right] \quad \text{Energy}$$

$$\frac{h}{\lambda} = \frac{h}{\lambda'} \cdot \cos\theta + p_e \cdot \cos\varphi \quad p_x$$

$$\frac{h}{\lambda'} \cdot \sin\theta = p_e \cdot \sin\varphi \quad p_y$$

$$\left(\text{Photon: } E = pc \Rightarrow p = \frac{E}{c} = \frac{hf}{c} = \frac{h}{\lambda}\right)$$

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

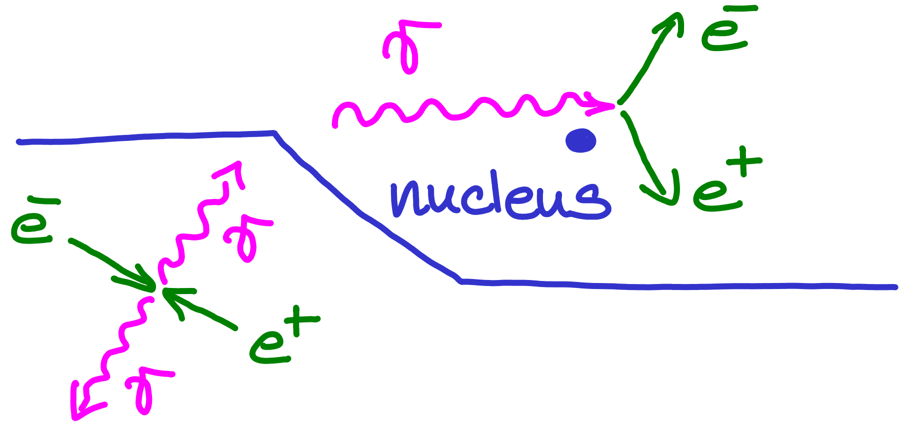
$$\frac{h}{m_e c} = \lambda_c = 2.426 \text{ pm}$$

λ_c: Compton wavelength of the electron.

Pair production, annihilation

$\gamma \rightarrow e^- + e^+$

$e^- + e^+ \rightarrow \gamma + \gamma$



e^+: positron, predicted by Paul Adrien Maurice Dirac (Nobel, 1933) and found by Carl David Anderson (Nobel, 1936).

$m_e c^2 = 0.511$ MeV : rest energy of the electron or the positron.

Pair productin: $hf > 2 m_e c^2 = 1.022$ MeV.

Annihilation : $2 m_e c^2 = 2hf \Rightarrow$

$\Rightarrow hf = m_e c^2 = 0.511$ MeV.

Application: PET : positron emission tomography.