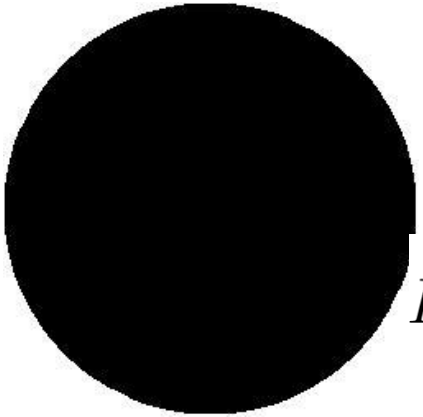
Copyright statement

- The images and the pictures in this lecture are provided by the CDs accompanied by the books

  1. University Physics, Bauer and Westfall, McGraw-Hill, 2011.
  2. Principles of Physics, Halliday, Resnick, and Walker, Wiley, 8th and 9th Ed.

- The rest is made by me.

Blackbody radiation



Classically known facts

(1) Stefan-Boltzmann law

$$I = \int_0^\infty \epsilon(\lambda) d\lambda = \sigma T^4, \quad \sigma = 5.67 \cdot 10^{-8} \mathrm{Wm}^{-2}\mathrm{K}^{-4}$$

(2) Wien's law

$$\epsilon_{\mathrm{Wien}} = \frac{a}{\lambda} e^{-b/\lambda T} \qquad \lambda_m T = \text{constant}$$

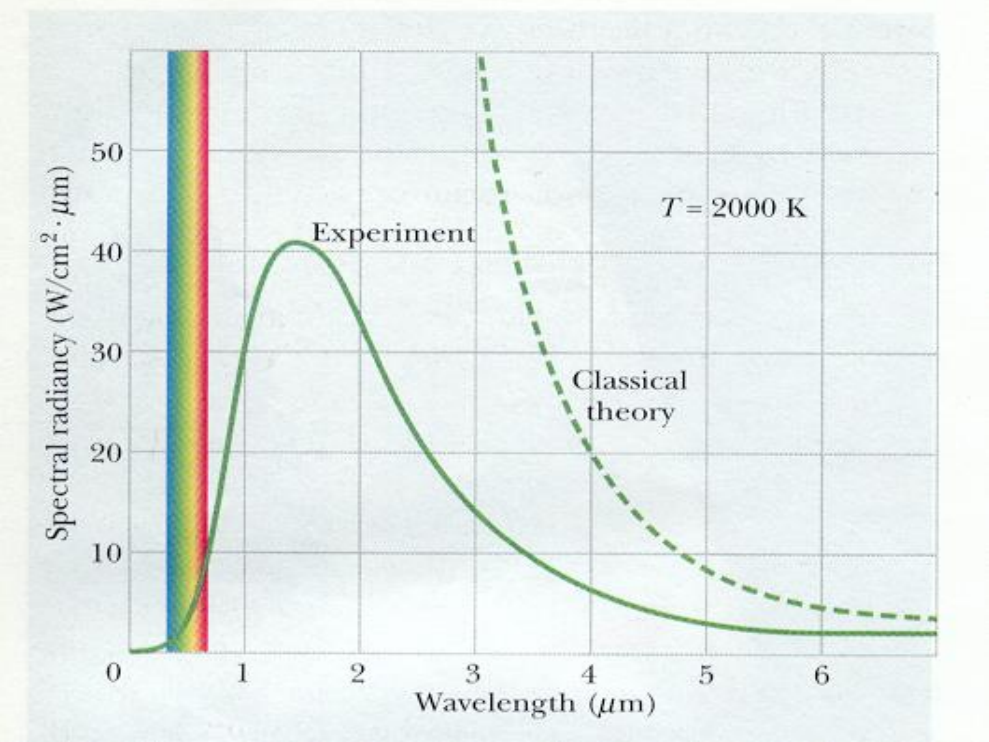
(3) Rayleigh-Jeans law

$$\epsilon_{\mathrm{RJ}} = \frac{2\pi c k_B T}{\lambda^4}$$

Planck got the result

$$\epsilon_T(\lambda) = \frac{2\pi hc^2}{\lambda^5\left(e^{hc/\lambda k_B T} - 1\right)}$$

빛은 파동이다. 아니다.



편광, 간섭, 회절

↓

전자기파동 이론

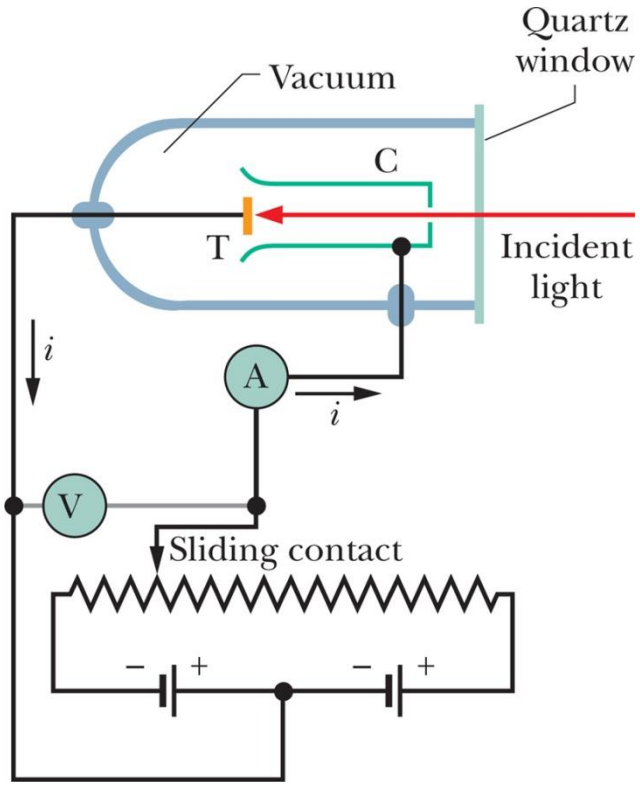
빛의 양자화 에너지

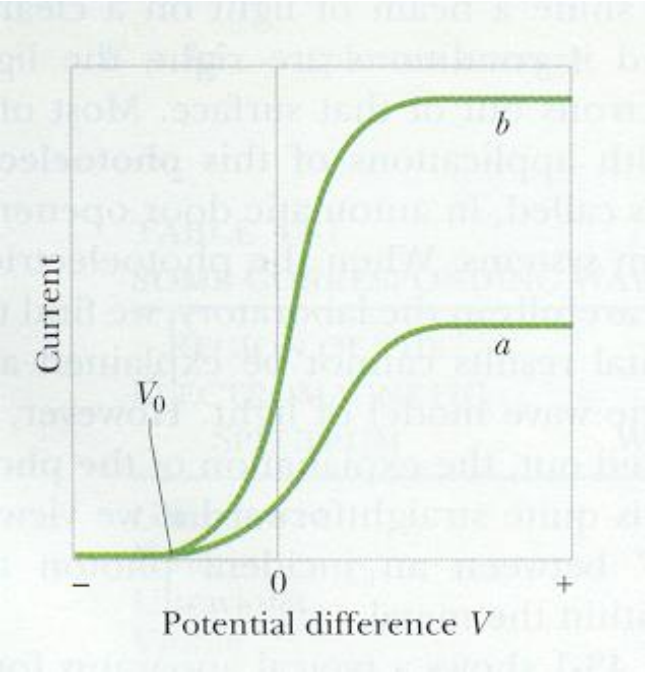
$$E = hf$$

$$yellow : \lambda = 589\text{nm} \Rightarrow E = hf = \frac{hc}{\lambda} = 2.11\text{eV}$$

$$\gamma - ray : E = 1.35\text{Mev} \Rightarrow \lambda = \frac{c}{f} = \frac{hc}{hf} = \frac{hc}{E} = 920\text{fm}$$

Photoelectric effect 1

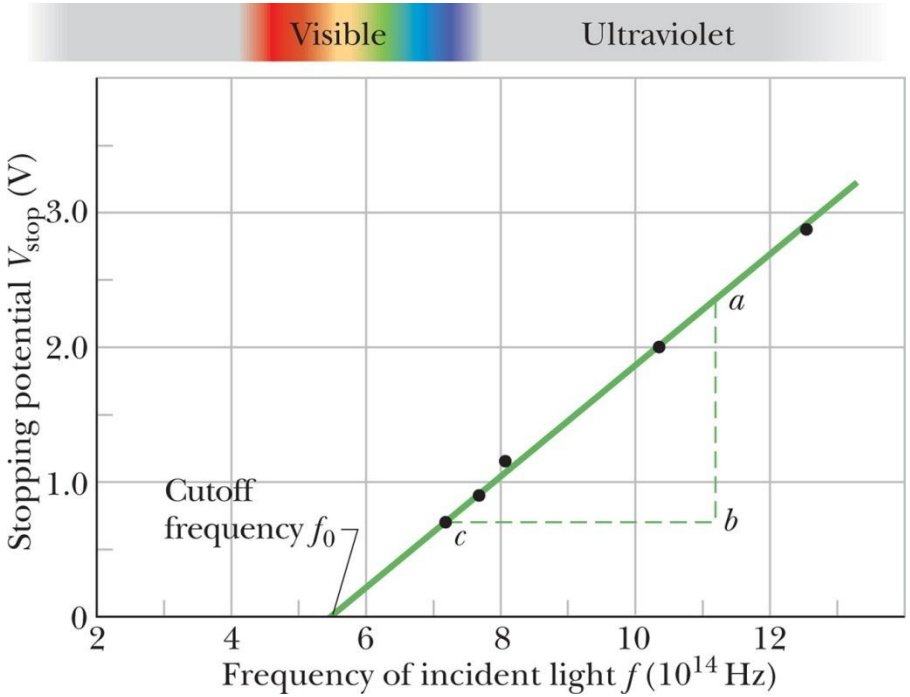


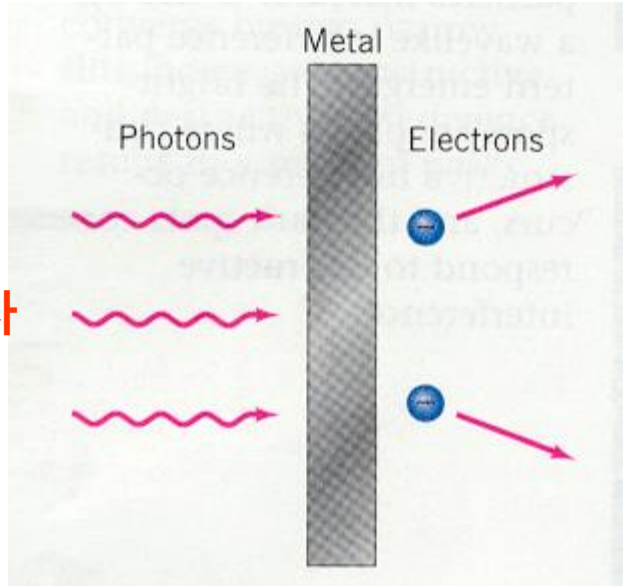


$$K_{\max} = eV_{\text{stop}}$$

(1) 주어진 진동수에 대해 최대 운동에너지는 빛의 세기와 무관하다.
(2) 빛이 세지면 나오는 전자의 수가 더 많아진다.
(3) 최대 운동에너지는 빛의 진동수와 관련이 있다.

Photoelectric effect 2





광자

$$hf = K_{\max} + \Phi$$

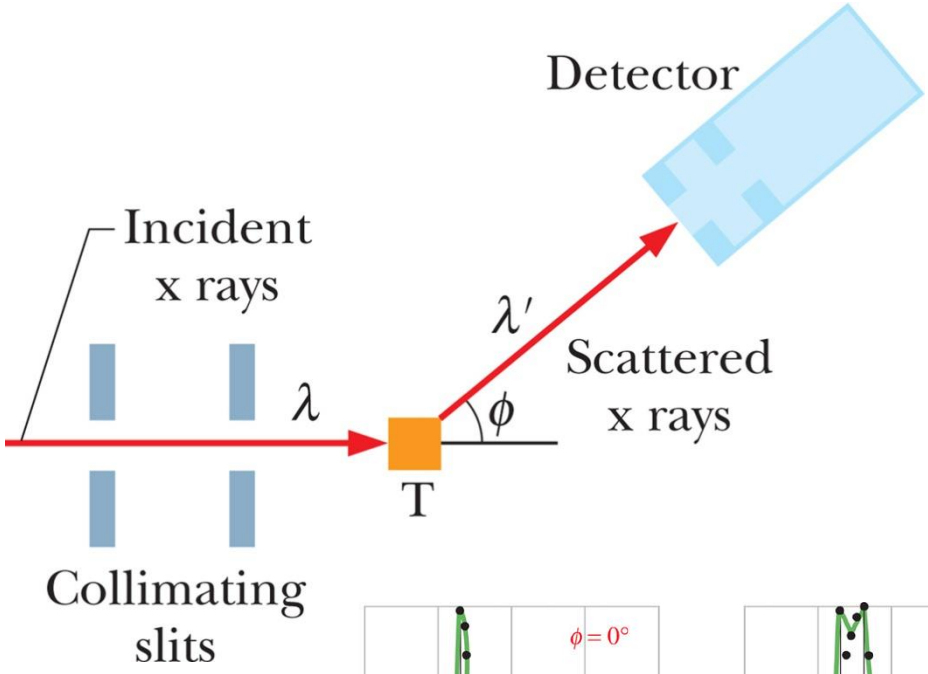
Φ : work function

$$V_{\text{stop}} = \frac{h}{e}f - \frac{\Phi}{e}$$

$$h = 6.63 \times 10^{-34}\ \text{J} \cdot \text{s}$$

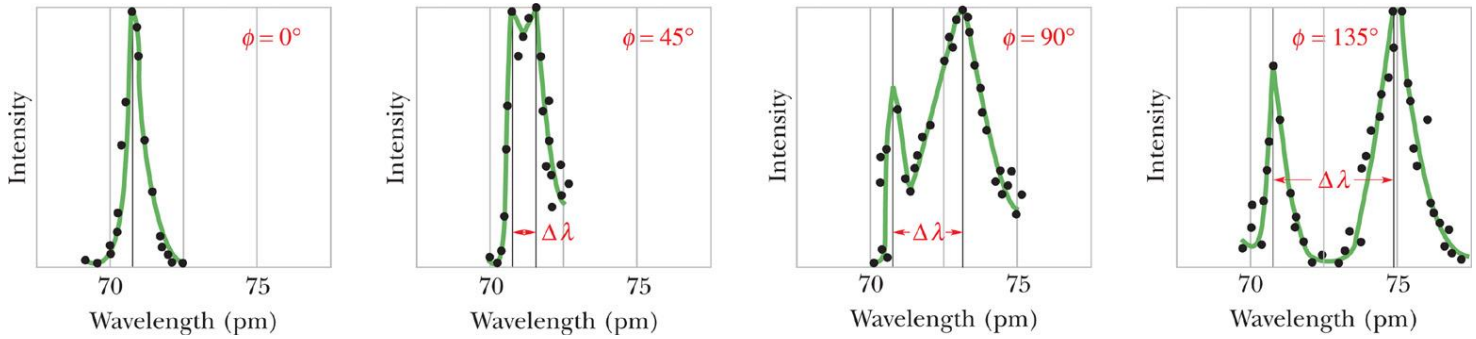
(1) Threshold freq.보다 큰 진동수의 빛만이 전자를 나오게 한다.
(2) 빛의 세기가 세더라도 threshold freq.보다 작으면 전자가 나오지 않는다.

Compton exp.:광자의 운동량

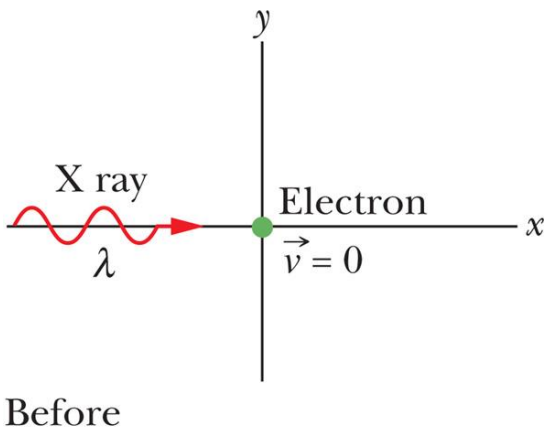


energy hf 인 photon의 운동량

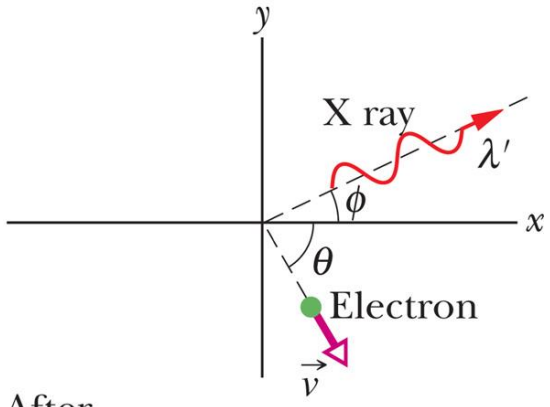
$$p = \frac{hf}{c} = \frac{h}{\lambda}$$



Compton 실험 분석



Before



After

$$hf = hf' + K \qquad K = mc^2(\gamma - 1)$$

$$\gamma = \frac{1}{\sqrt{1 - v^2/c^2}}$$

$$hf = hf' + mc^2(\gamma - 1)$$

$$\frac{h}{\lambda} = \frac{h}{\lambda'} + mc(\gamma - 1)$$

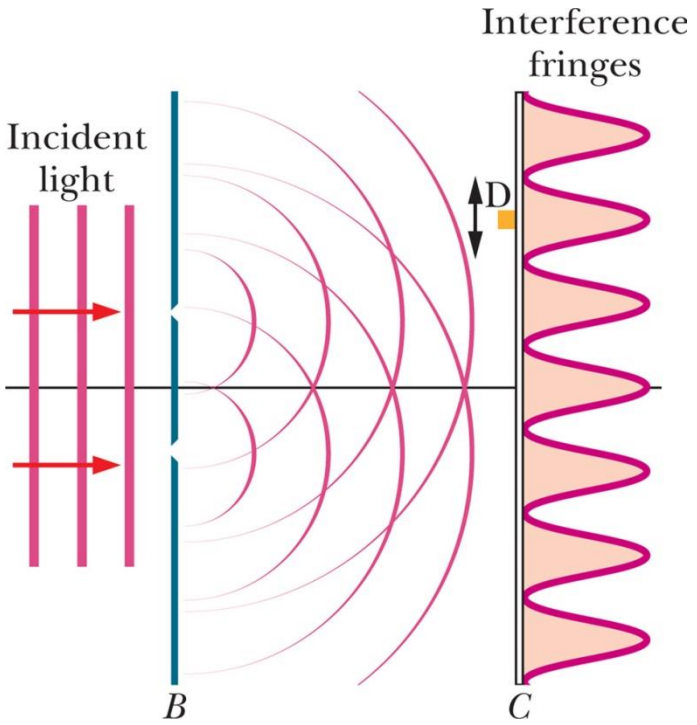
$$\frac{h}{\lambda} = \frac{h}{\lambda'}\cos\phi + \gamma mv\cos\theta$$

$$0 = \frac{h}{\lambda'}\sin\phi - \gamma mv\sin\theta$$

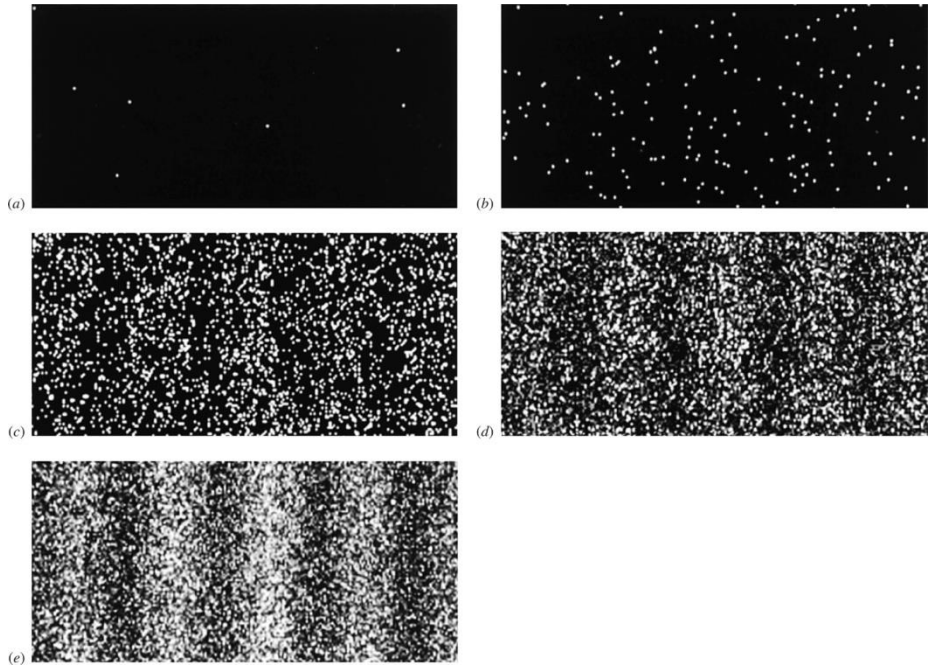
$$\Delta\lambda = \lambda' - \lambda = \frac{h}{mc}(1 - \cos\phi)$$

빛의 파동적 성질

(1) 기본적 실험



(2) 단일 광자 실험



광자를 발견할 확률

$$P \propto I \propto E^2$$