United Nations

Women and Girls in Science Day 2023

Science Day at Depot Park

February 11, 10am-noon

Engage with STEM demos and activities hosted by UF student organizations

PUBLIC LECTURE - February 10, 6-7PM

"*Exploration science - going boldly in* ***plant space biology***"

Dr. Anna-Lisa Paul

UF, Director of ICBR
IFAS Horticultural Sciences

New Physics Building
2001 Museum Road
Room 1001

UF
UNIVERSITY of FLORIDA
Department of Physics

Announcements

Homework 3 due on Feb 8 (next Wednesday).

Exam 1 is coming up! Feb 17. Start preparing NOW!

Last time

- Black body radiation
- Stefan-Boltzmann Law
  Total intensity I= σT^4
- Wien's Displacement Law:
  λmax T=constant
- Planck's prediction $$I(\lambda) = \frac{2\pi hc^2}{\lambda^5} \frac{1}{e^{hc/\lambda kT} - 1}$$

Today

- Compton effect
- Review the wave nature of EM radiation

in-class quiz (3 min)

An object at temperature 200K radiates 100W of power. How much power would it emit if the temperature were changed to 600K?

a. 900 W

b. 300 W

c. 100 W

d. 2700 W

e. 8100 W

in-class quiz (3 min)

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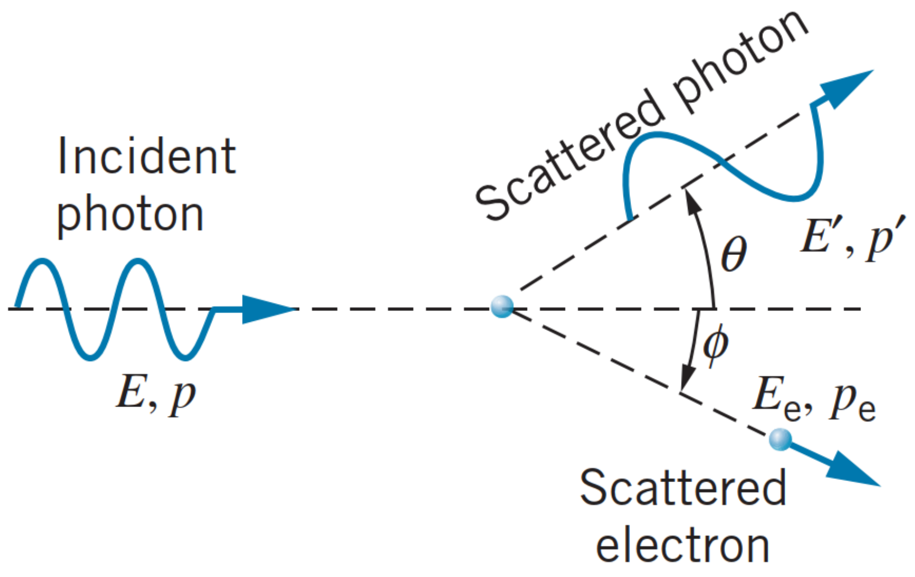
$I \propto T^4$

$3^4 = 81$

Meet today's Nobel laureate: Author Compton

The Nobel Prize in Physics 1927 was divided equally between Arthur Holly Compton "**for his discovery of the effect named after him**" and Charles Thomson Rees Wilson "for his method of making the paths of electrically charged particles visible by condensation of vapour."

Compton scattering



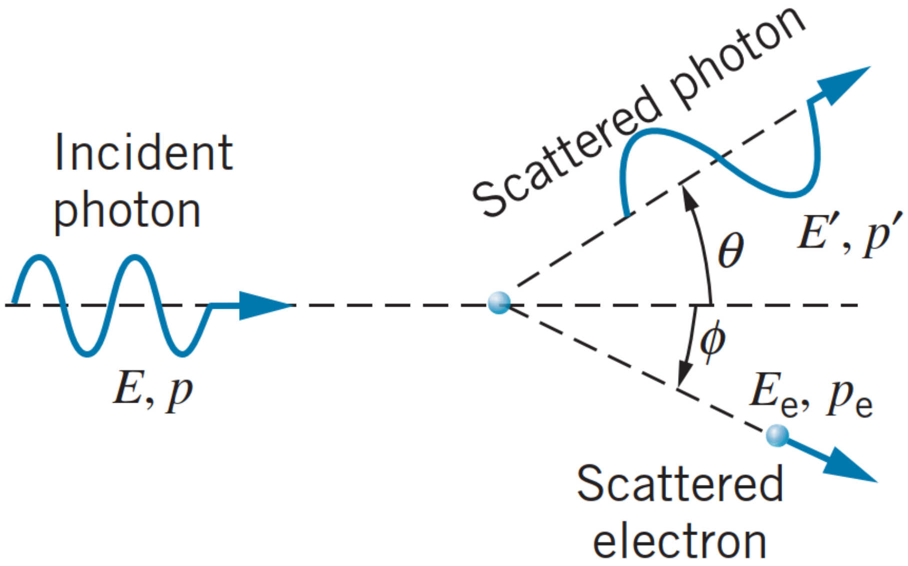
"Wave" picture for scattering between light and material:

- the scattered radiation is less energetic than the incident radiation
- energy difference goes into the kinetic energy of the electron
- same wavelength

"Photon" picture for scattering between light and material:

- the scattered radiation is less energetic than the incident radiation
- energy difference goes into the kinetic energy of the electron
- frequency of photon decreases

Compton scattering



Energy conservation and momentum conservation:

<u>Before the scattering:</u>

photon with energy E, momentum p

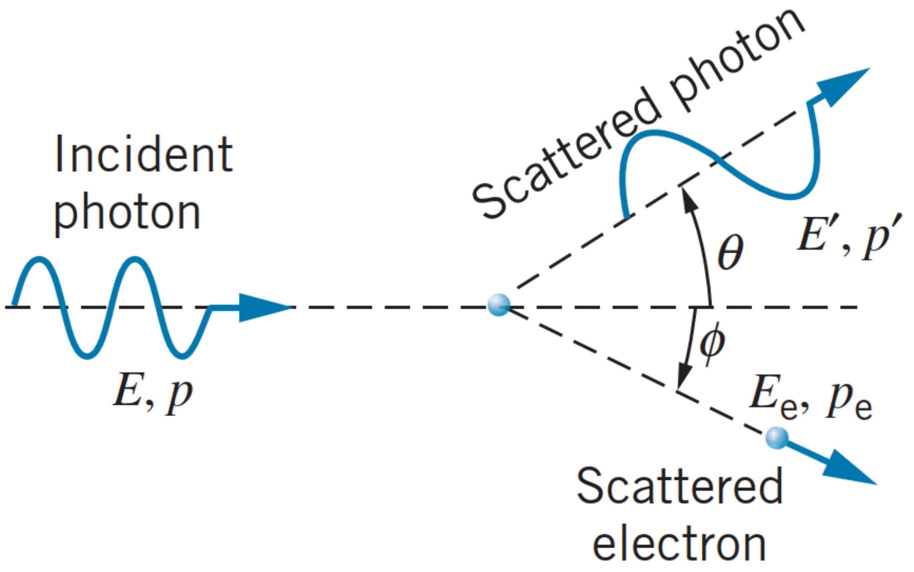
the target electron is at rest, only has rest energy

<u>After the scattering:</u>

photon E’, p’

electron starts moving total energy Ee, momentum Pe

In class exercise (5 min) - what is E' or λ'



We want to combine Einstein's **special relativity** and his **quantum photon** hypothesis to solve this.

Energy conservation and momentum conservation:

Before the scattering:

photon with energy E, momentum p

the target electron is at rest, only has rest energy

After the scattering:

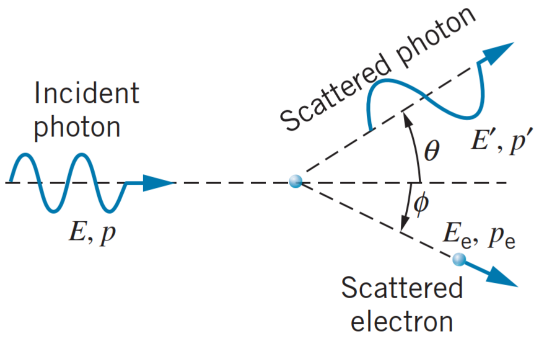
photon E', p'

electron starts moving total energy Ee, momentum Pe

physical hint:

- momentum conservation in both x and y directions.
- What is the relationship between Ee and Pe?

mathematical hint: $\cos^2\phi + \sin^2\phi = 1$



$$E_{initial} = E_{final} \Rightarrow E + m_e c^2 = E' + E_e$$

$$p_{x,\,initial} = p_{x,\,final} \Rightarrow p = p'\cos\theta + p_e\cos\phi$$

$$p_{y,\,initial} = p_{y,\,final} \Rightarrow 0 = p'\sin\theta - p_e\sin\phi$$

$$\left.\begin{aligned}(p_e\cos\phi)^2 &= (p - p'\cos\theta)^2 \\ (p_e\sin\phi)^2 &= (p'\sin\theta)^2 \\ \cos^2\phi + \sin^2\phi &= 1\end{aligned}\right\} \quad p_e^2 = p^2 - 2pp'\cos\theta + p'^2$$

$$E = \sqrt{(pc)^2 + (mc^2)^2} \Rightarrow E_e = \sqrt{(p_e c)^2 + (m_e c^2)^2} \Rightarrow E_e^2 = c^2 p_e^2 + m_e^2 c^4$$

$$E_e^2 = (E + m_e c^2 - E')^2 = c^2(p^2 - 2pp'\cos\theta + p'^2) + m_e^2 c^4$$

$$\frac{1}{E'} - \frac{1}{E} = \frac{1}{m_e c^2}(1 - \cos\theta)$$

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

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

Compton scattering

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

$$\frac{h}{m_e c}$$

Compton wavelength of the electron

This is a **change** in wavelength

- Use the convenient energy units

$$\frac{hc}{m_e c^2}$$

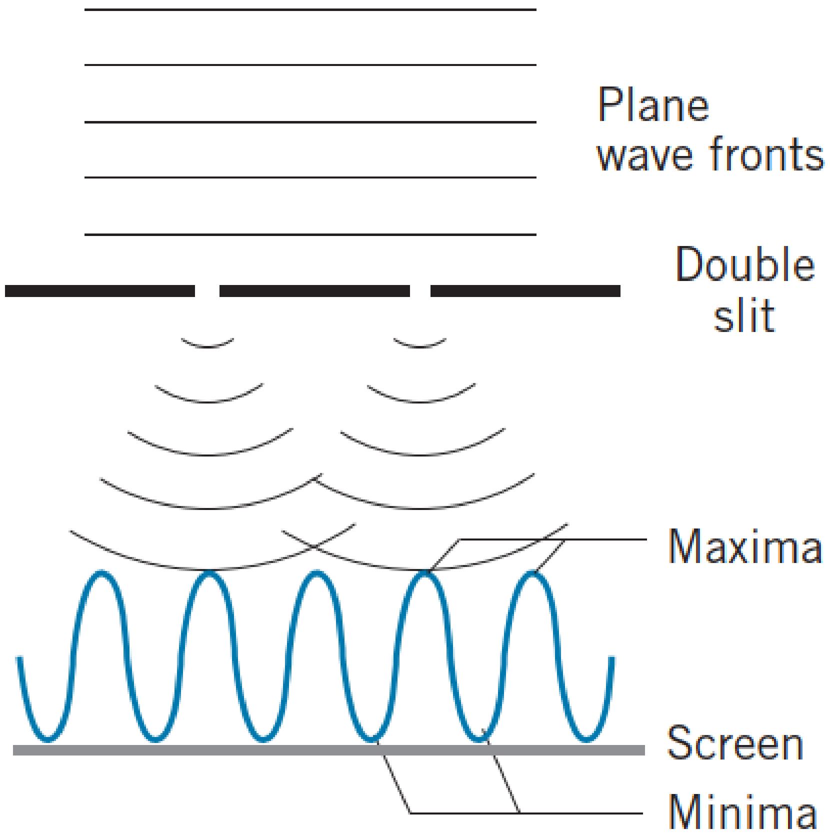
$$hc = 1240 \text{ eV} \times \text{nm}$$

$$m_e c^2 = 5.11 \times 10^5 \text{ eV}$$

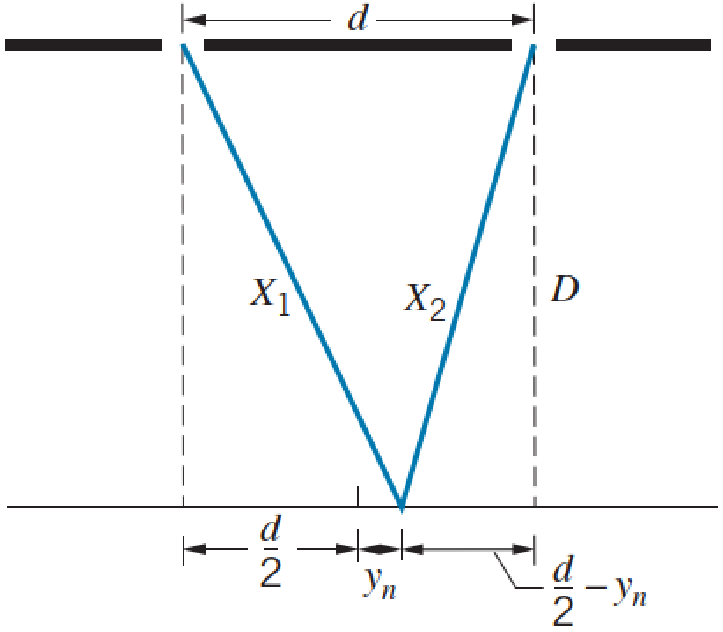
- the shift in wavelength (in nm)

$$\Delta\lambda = \frac{hc}{m_e c^2}(1 - \cos\theta) = 0.00243(1 - \cos\theta)$$

Recall the wave properties of electromagnetic radiation: Young's double slit interference



Young's double slit interference



$|X1\text{-}X2| = n\lambda$ constructive interference

$|X1\text{-}X2| = (n+1/2)\lambda$ destructive interference

Next time

Chapter 4

THE WAVELIKE PROPERTIES OF PARTICLES