GAMMA RAYS

- MOST α & β DECAYS LEAVE FINAL NUCLEUS IN AN EXCITED STATE, WHICH QUICKLY DECAY TO GROUND STATE WITH 1 OR MORE γ-RAYS.

- TYPICAL ENERGY IS BETWEEN 0.1 & 10 MeV ($\lambda \sim 10^4 \to 10^2$ fm) COMPARE TO VISIBLE LIGHT OF 10^6 X LONGER IN WAVE LENGTH.

- CONS OF E

INITIAL EXCITED STATE → E_i; E GAMMA RAY → E_γ

$$E_i = E_f + E_\gamma + T_R$$

E OF FINAL STATE → E_f; RECOIL KINETIC ENERGY → T_R

- CONS OF P $\quad 0 = \vec{P}_R + \vec{P}_\gamma \quad$ OR $\quad P_R = P_\gamma$

$$\Delta E = E_i - E_f$$

$$E_\gamma = c P_\gamma$$

$$\Delta E = E_\gamma + \frac{E_\gamma^2}{2Mc^2}$$

$$E_\gamma = Mc^2\left[-1 \pm \left(1 + 2\frac{\Delta E}{Mc^2}\right)^{1/2}\right]$$

$\Delta E \approx$ MeV

$Mc^2 \approx 10^3 \cdot A$ MeV

$\Delta E \ll Mc^2$

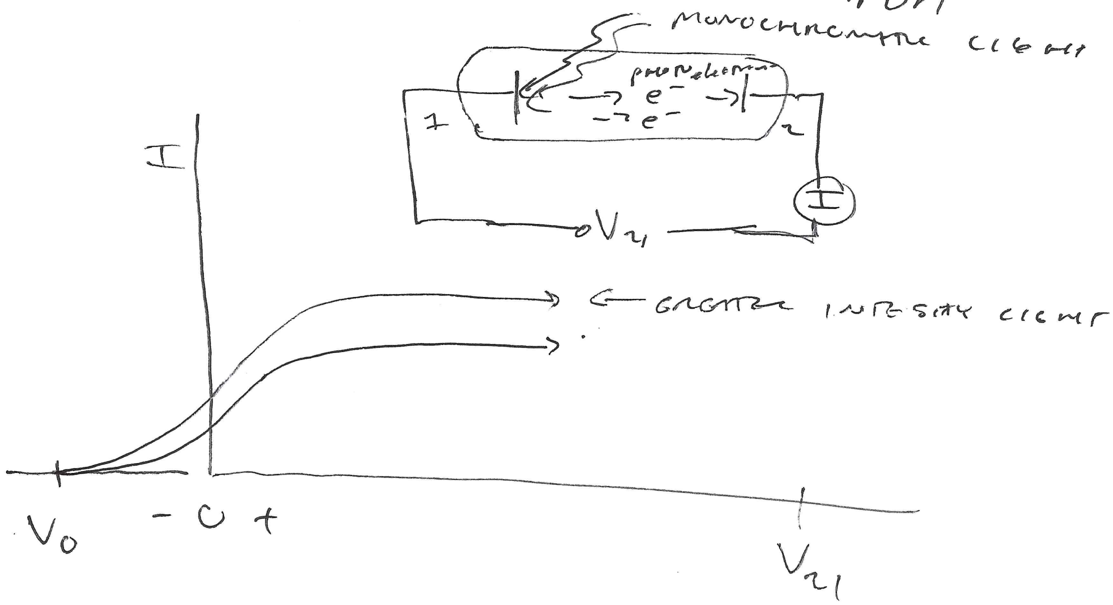
IN EXPANSION KEEP 1ST TERM

$$E_\gamma \cong \Delta E - \frac{(\Delta E)^2}{2Mc^2} \Longrightarrow E_\gamma \cong \Delta E$$

RECOIL NUCLEAR ENERGY HIGH ENERGY γ (5-10 MeV) GIVES RECOIL ENERGY ~100 eV WHICH CAN LEAD TO DISPLACING THE ATOM IN A LATTICE, THIS IS RADIATION DAMAGE

PHOTO ELECTRIC EFFECT

ejection of electrons from absorbtion of an electron



INCIDENT LIGHT ARRIVES IN DISCRETE QUANT HAVING ENERGY

$$E = h\nu \quad h \text{ planks const.}$$

PHOTO ELECTRON IS PRODUCED FROM FULLY ABSORBE PHOTON.

K.E. EMITTED IS

$$T = h\nu - \phi$$

$$T_{max} = h\nu - \phi_0$$

↑ PHOTON ENERGY

↑ WORK FUNCTION

EXAMPLE

- WHAT THRESHOLD ENERGY MUST γ HAVE TO PRODUCE A PHOTOELECTRON FROM Al?

$$\varphi_0 = 4.20$$

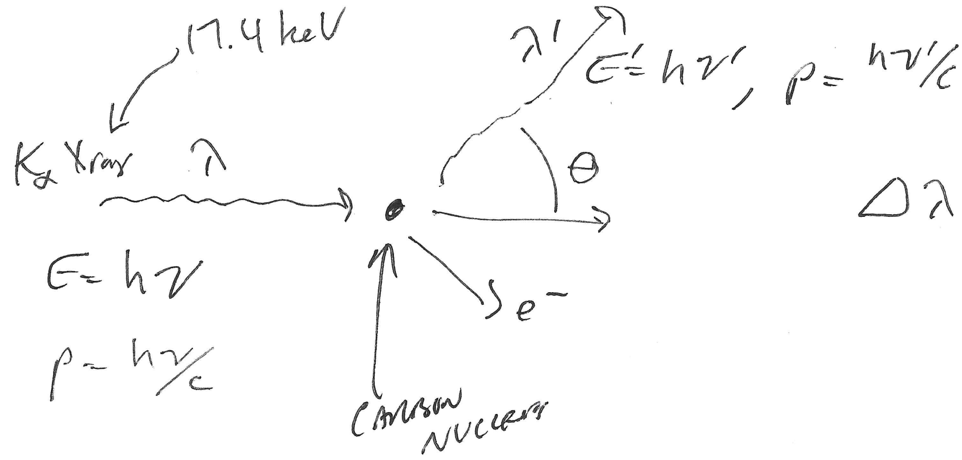
- MAXIMUM ENERGY EJECTED FROM Al by UV 1500Å

$$E = h\nu = \left(\frac{hc}{\lambda}\right) = \frac{1240\,\text{nm}\cdot\text{eV}}{150\,\text{nm}} = 8.27\,\text{eV}$$

- HOW DOES MAX ENERGY OF P.E. VARY WITH INTENSITY?

COMPTON SCATTERING

$\nu = c/\lambda$

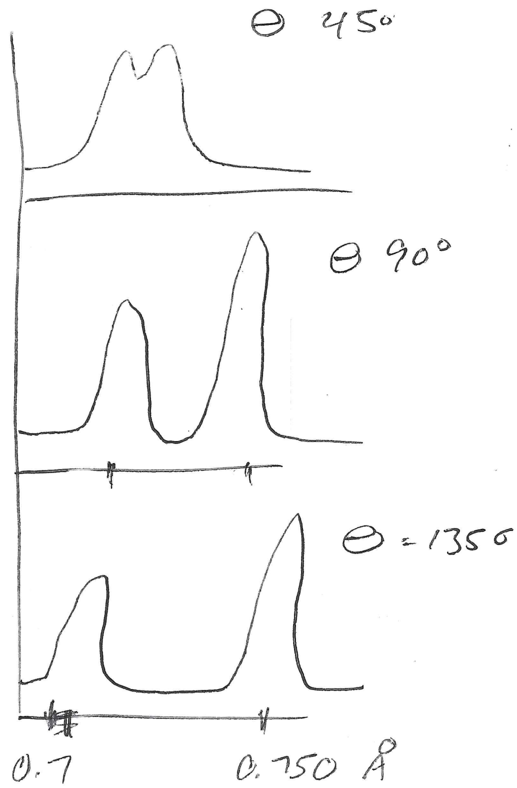


$\Delta\lambda = \lambda' - \lambda$

IN 1922 COMPTON SHOWED

$\Delta\lambda$ DEPENDED ONLY ON θ

0.024 Å @ $\theta = 90°$



CONS. OF TOTAL ENERGY

$$h\nu + mc^2 = h\nu' + E'$$

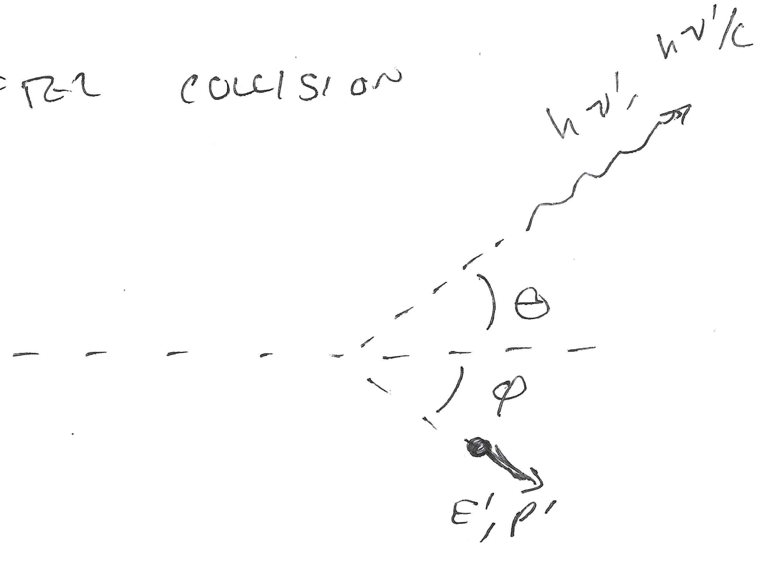
CONS OF MOMEMENTUM IN HORIZONTAL + VERTICA DIRECTIONS

$$\frac{h\nu}{c} = \frac{h\nu'}{c}\cos\theta + p'\cos\phi$$

$$+ \quad \frac{h\nu'}{c}\sin\theta = p'\sin\phi$$

BEFORE COLLISION:

AFTER COLLISION



ELIMINATING p' + ϕ FROM THESE EQUATIONS

$$h\nu' = \frac{h\nu}{1 + (h\nu/mc^2)(1 - \cos\theta)}$$

FIND COMPTON SHIFT "$\Delta\lambda$"

$$\Delta\lambda = \lambda' - \lambda = c\left(\frac{1}{\nu'} - \frac{1}{\nu}\right) = \frac{h}{mc}(1 - \cos\theta)$$

For ^{60}Co

1.332 SCATTERED @ ~ 140°

E of SCATTERED GAMMA

$$h\nu' = \frac{1.332\,\text{MeV}}{1 + \left(\frac{1.332}{0.511}\right)(1 - (-0.766))} = 0.238\ \text{MeV}$$

PAIR PRODUCTION

γ of E $h\nu \geq 2mc^2$ IN FIELD OF A NUCLEUS

$e^+ e^-$ PAIR

$$h\nu = 2mc^2 + T_+ + T_-$$

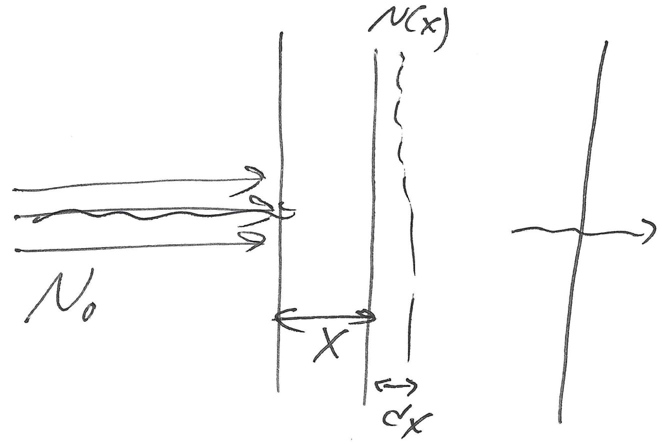
PAIR PRODUCTION ~~GOES~~ PROBABILITY GOES WITH Z^2

PHOTON ATTENUATION

PHOTO PENETRATION INTO MATTER IS STATISTICAL. PROB OF INTERACTION PER UNIT DISTANCE: μ [cm^{-1}]

MASS ATTENUATION COEFF μ/ρ [cm^2/g]

$$dN = -\mu N dx$$



$$dN = -\mu N dx$$

$$N(x) = N_0 e^{-\mu x}$$

$$\frac{N}{N_0} = e^{-\mu x}$$

"PROBABILITY A PHOTON WILL TRAVERSE SLAB X W/O INTERACTING