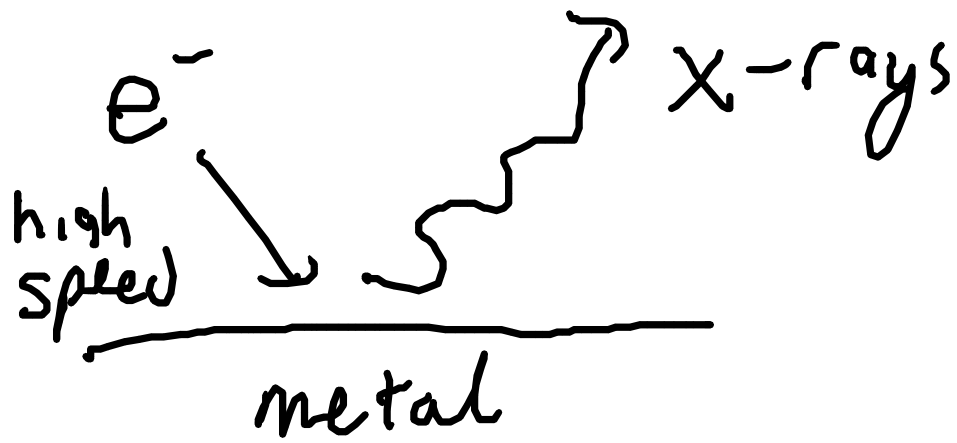


Bremsstrahlung

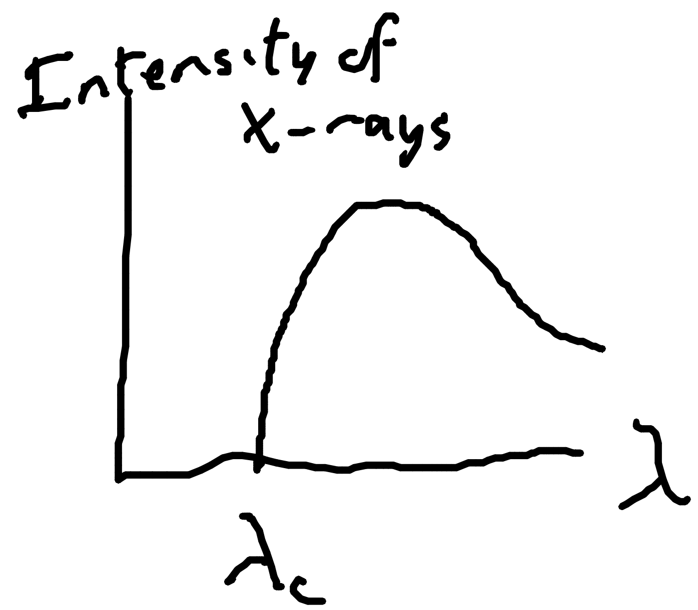
braking radiation

Predicted from classical EM

but wavelength of light should be arbitrary

(b/c energy = intensity for a wave)

Seen



no ~~xx~~ X-rays below a cutoff wavelength.

minimum wavelength $\rightarrow$ maximum photon energy

$\Rightarrow$ electron KE is used to create a photon

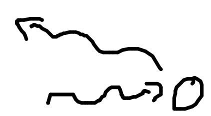
so $\frac{hc}{\lambda} \leq KE_{max}$ for any electron

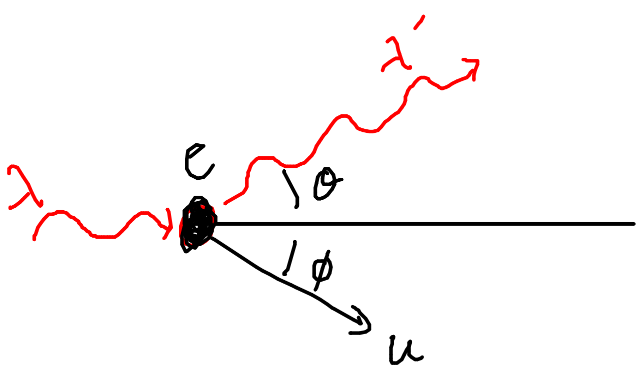
Compton Effect

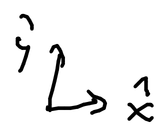
light reflected off of free electrons

Classic: electrons would resonate at frequency of the light, & re-emit light in all directions at same frequency

Compton: experimented
no, radiation that bounced backwards had smaller f or larger λ







Initial

photon
$E = h\frac{c}{\lambda}$
$p = \frac{E}{c} = \frac{h}{\lambda}\hat{x}$

electron
$E = mc^2$
$p = 0$

Final

Photon
$E = \frac{hc}{\lambda'}$
$p = \frac{h}{\lambda'}(\cos\theta\,\hat{x} + \sin\theta\,\hat{y})$

electron
$E = \gamma_u mc^2$
$p = \gamma m u \begin{pmatrix}\cos\phi\,\hat{x} \\ -\sin\phi\,\hat{y}\end{pmatrix}$

initial energy & momentum = final energy & momentum

$$\lambda' - \lambda = \frac{h}{mc}(1 - \cos\theta) \qquad (\text{cf HW})$$

$\theta = 0$ $\quad \lambda' = \lambda$

$\theta = 90°$ $\quad \lambda' = \lambda + \frac{h}{mc}$

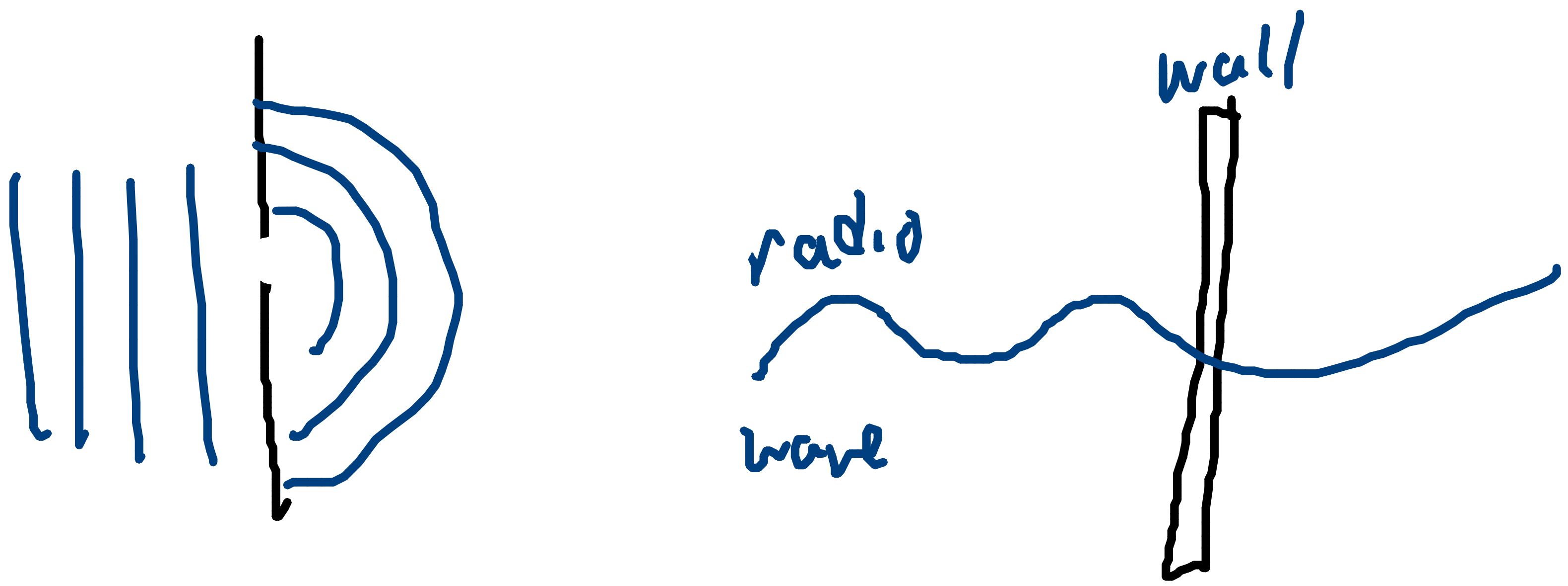
$\theta = 180°$ $\quad \lambda' = \lambda + 2\frac{h}{mc}$

scattered photon always has longer λ, less energy

When does light act like a wave?

if $\lambda > D$ ← dimensions of the apparatus you're using to study the light

acts like a wave



if $\lambda < D$, acts like a particle