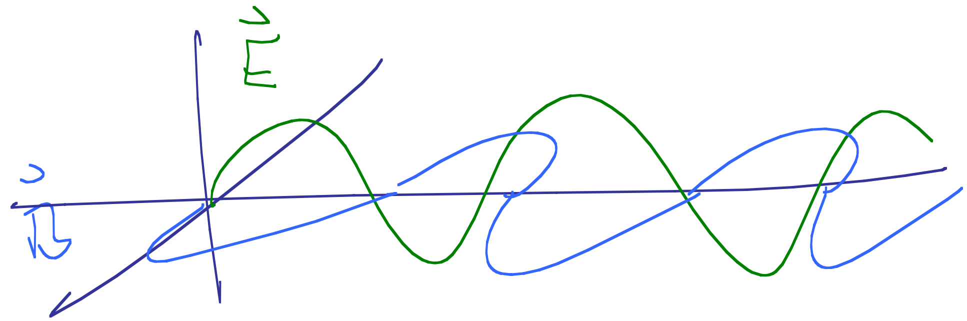
Phys 2120-4 11/9/12

Note Title 11/9/2012

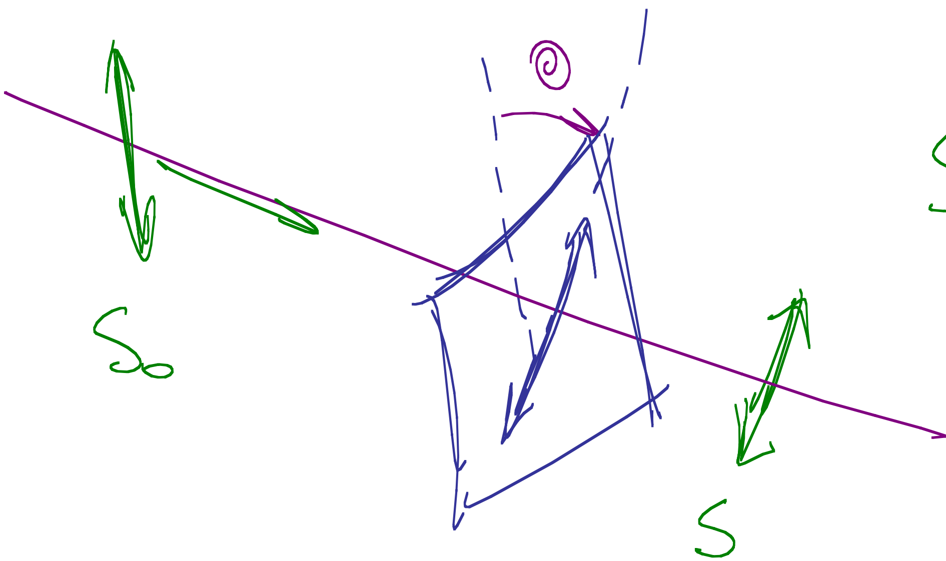
EM waves.

$$\lambda f = c$$



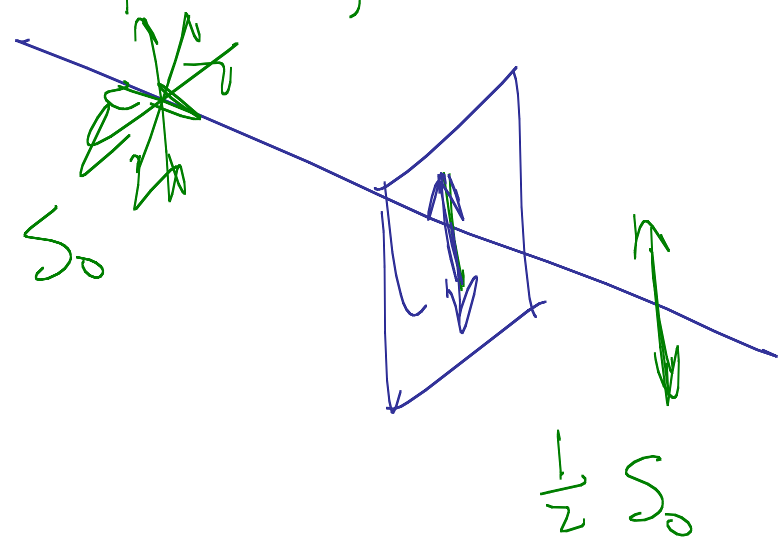
$$E = cB$$

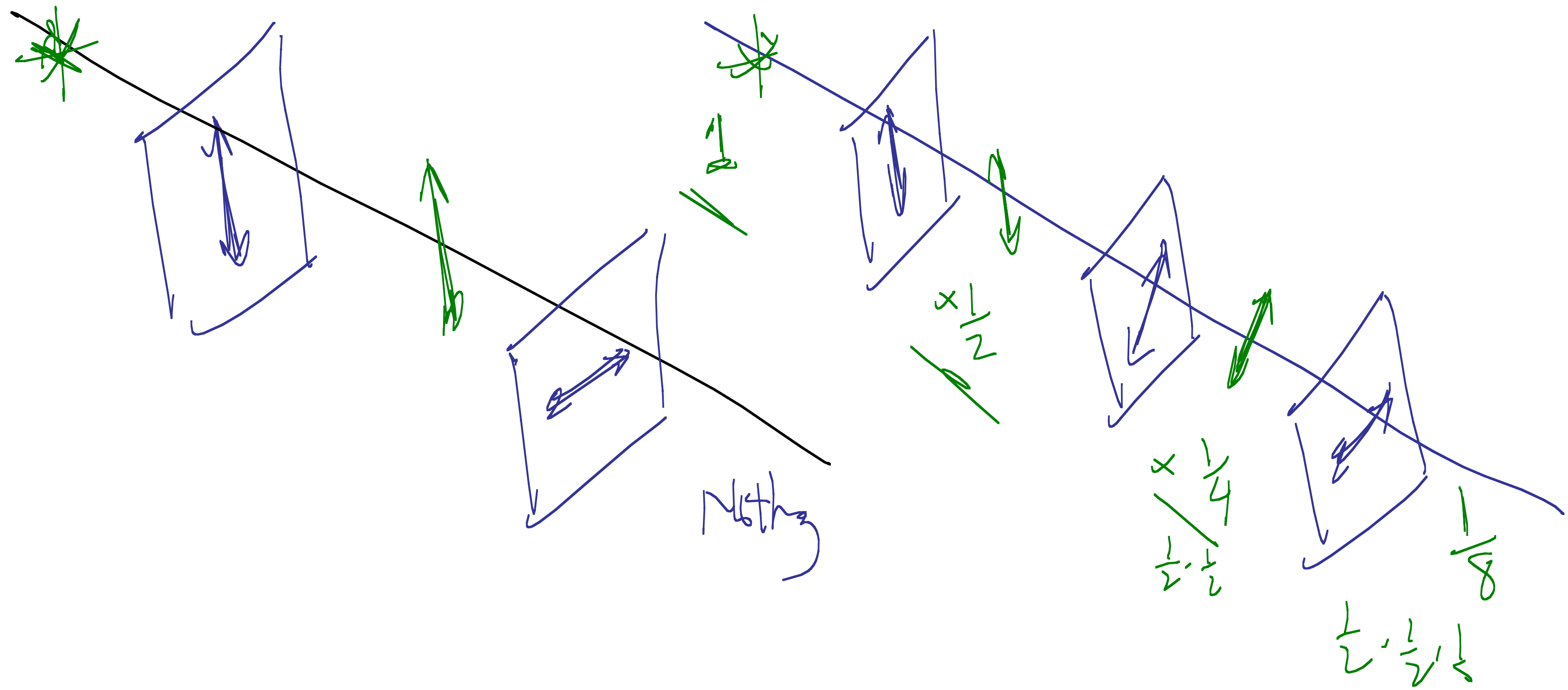
Polarization.



$$S = \cos^2\theta \, S_0$$

Unpolarized,

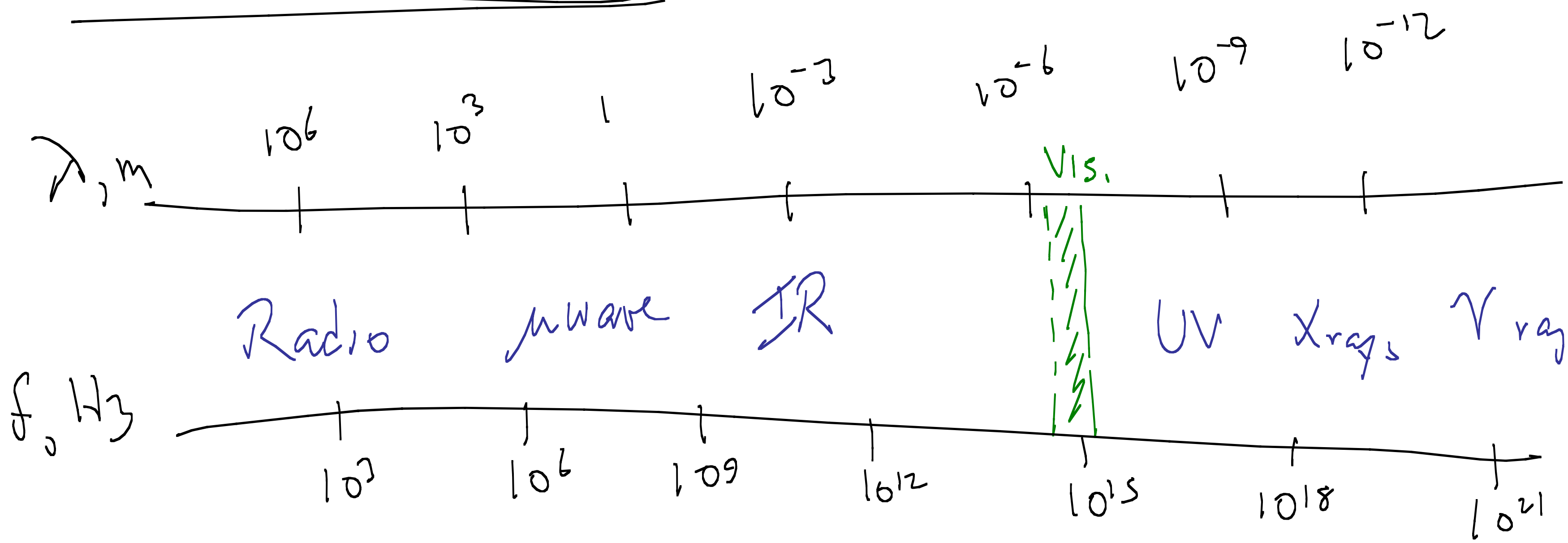




1
Nothing
× 1/2
× 1/4
1/2 · 1/2
1/8
1/2 · 1/2 · 1/2

EM Spectrum

$\lambda f = c$



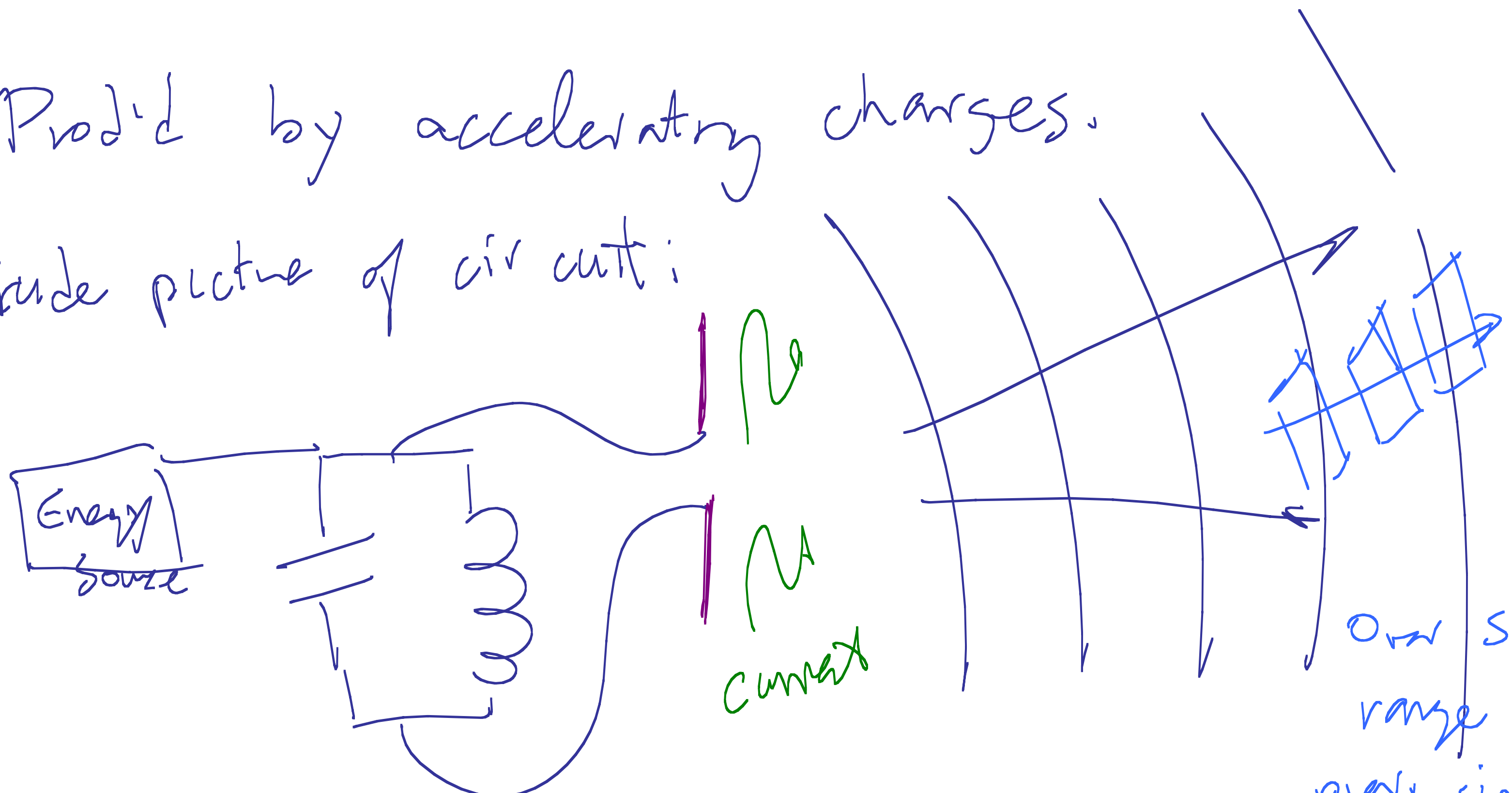
Radio, μwaves: Macroscopic osc's of currents

IR, Vis, UV, Molec, Atomics

Xrays γ-rays Atomic Nuclear

Prod'd by accelerating charges.

Crude picture of circuit:



Over small range preview prev. simple picture is ok

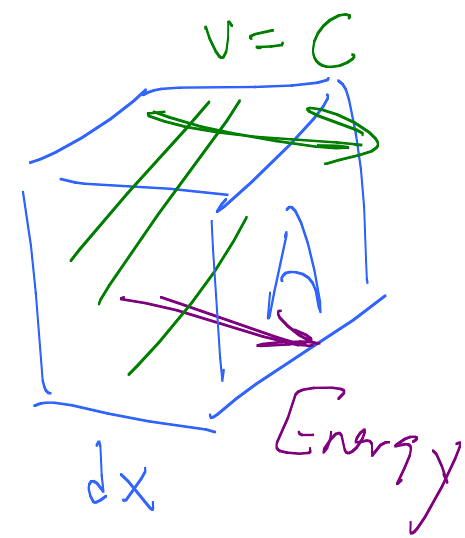
Energy & Momentum in EM Waves

Wave char'd by intensity

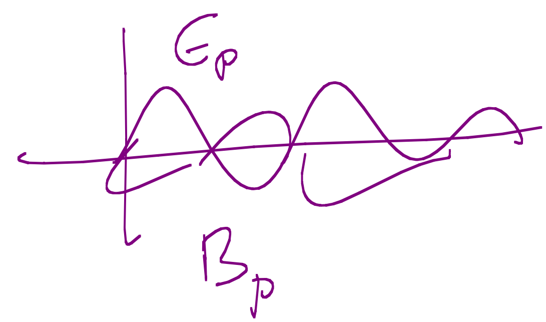
$$\frac{\text{Energy}}{\text{Time Area}} = \frac{W}{m^2} = [S] \quad \text{intensity}$$

Relate S to E_p B_p

Amt of energy in box



Vol = A dx



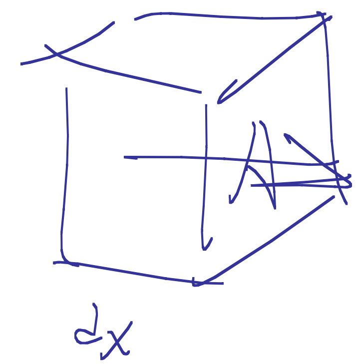
$$dU \equiv (u_E + u_B)\underbrace{A\,dv}_{V} = \frac{1}{2}\left(\epsilon_0 E^2 + \frac{B^2}{\mu_0}\right) A\,dx$$

Rate at which Energy passes thru face:

$$\frac{dU}{dt} = \frac{1}{2}\left(\epsilon_0 E^2 + \frac{B^2}{\mu_0}\right)\frac{A\,\cancel{dx}}{\cancel{dx}/c}$$

$$\frac{dx}{dt} = v = c$$

$$dt = \frac{dx}{c}$$



$$S = \frac{dU/dt}{A} = \frac{c}{2}\left(\epsilon_0 E^2 + \frac{B^2}{\mu_0}\right)$$

Use

$E = cB \quad B = E/c$

Got

$$S = \frac{1}{2\mu_0}\left(\epsilon_0 \mu_0 c + 1\right) E B = \frac{EB}{\mu_0}$$

$\epsilon_0 \mu_0 = \frac{1}{c}$ $\quad c = \frac{1}{\sqrt{\epsilon_0 \mu_0}}$

Poynting

S is vector $\quad \vec{S} = \vec{E} \times \vec{B} / \mu_0$

Want avg of S

Also $\overline{B^2} = B_{rms}^2$

Recall = $\overline{E^2} = \frac{1}{2} E_p^2 = E_{rms}^2$

$\overline{EB} = E_{rms} B_{rms}$

$$\bar{S} = \frac{\bar{E}\bar{B}}{\mu_0} = \frac{E_\varphi B_\varphi}{2\mu_0} = \bar{S} = \frac{E_\varphi^2}{2\mu_0 c} = \frac{c B_\varphi^2}{2\mu_0}$$

$$\frac{\text{Amt energy}}{\text{Area Time}}$$

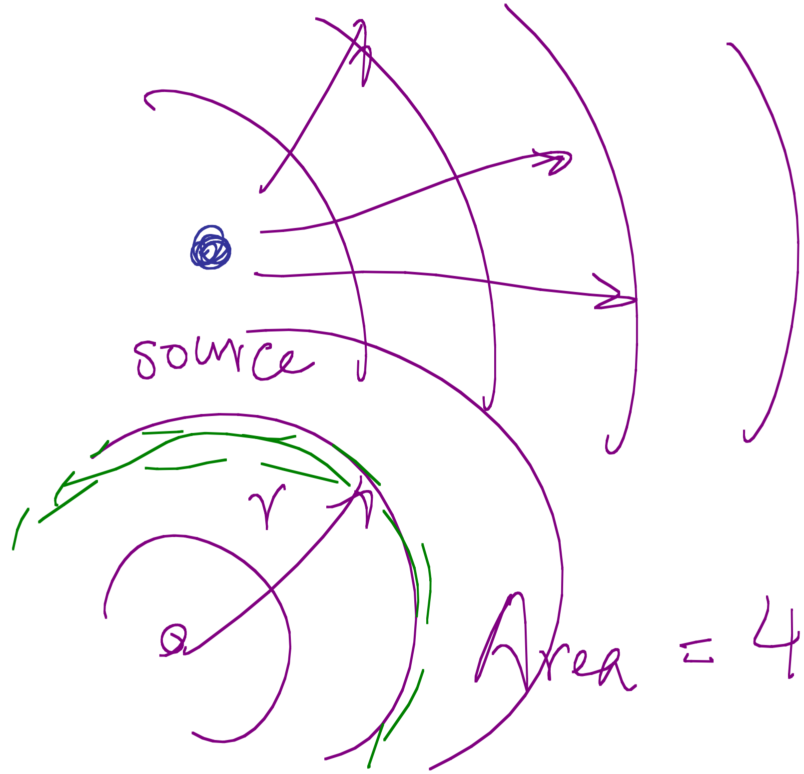
Localized Source (Isotropic)

E_p, B_p

$\propto \sqrt{S}$

E_p, B_p

$\propto 1/r$



Area $= 4\pi r^2$

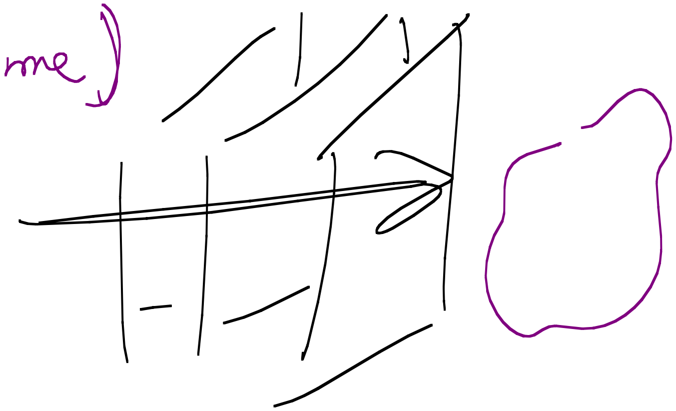
Suppose source puts out energy at a <u>rate</u> P

Stand distance r away

$$S = \frac{P}{4\pi r^2}$$

$$\propto \frac{1}{r^2}$$

EM fields carry momentum (per area per time)

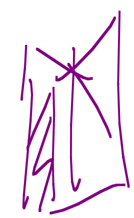


Momentum & energy related

$$p = U/c$$

Force/area from EM wave $= \vec{S}/c$ = pressure

Object in path of beam feels force



reflects $= 2S/c$