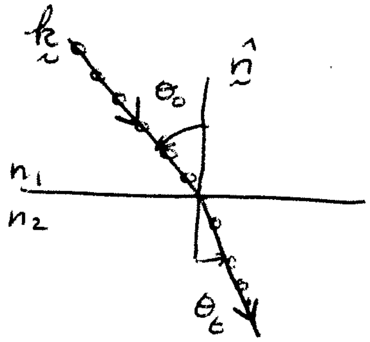
1/25/10 FRESNEL EQUATIONS → POLARIZED LIGHT



TE, ⊥, s

$$r_{TE} = \frac{\underline{n_1} \cos \underline{\theta_0} - n_2 \cos\theta_t}{n_1 \cos\theta_0 + n_2 \cos\theta_t}$$

$$t_{TE} = \frac{2n_1 \cos\theta_0}{n_1 \cos\theta_0 + n_2 \cos\theta_t}$$

$$\theta_t = \sin^{-1}\left(\frac{n_1}{n_2} \sin\theta_0\right)$$

TM, ∥, P

$$r_{TM} = \frac{\underline{n_2} \cos \underline{\theta_0} - n_1 \cos\theta_t}{n_2 \cos\theta_0 + n_1 \cos\theta_t}$$

$$t_{TM} = \frac{\boxed{2n_1 \cos\theta_0}}{n_2 \cos\theta_0 + n_1 \cos\theta_t}$$

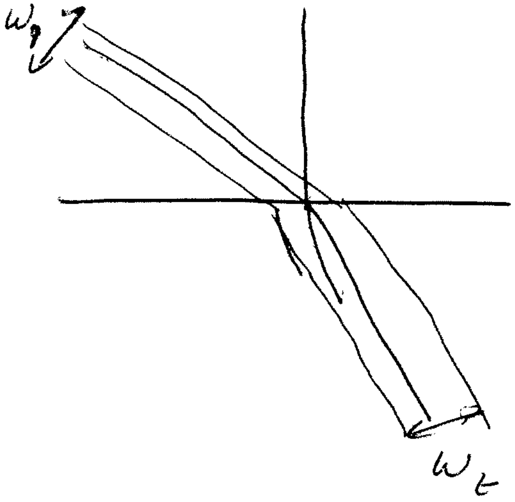
R = REFLECTANCE → RATIO OF REFLECTED TO INCIDENT POWER

$= (r)^2$

$R_{TE} = r_{TE}^2$

$R_{TM} = r_{TM}^2$

T TRANSMITTANCE $\boxed{T = 1 - R}$

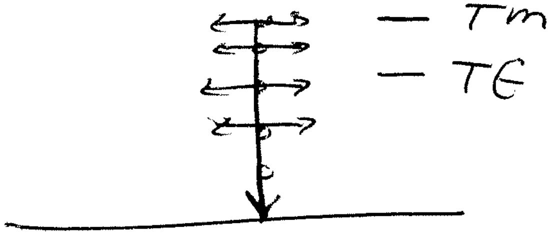


~~t_{TE}~~ $$T_{TE} = (t_{TE})^2 \cdot \left(\frac{n_2 \cos\theta_t}{n_1 \cos\theta_0}\right)$$

$$T_{TM} = (t_{TM})^2 = \left(\frac{n_2 \cos\theta_t}{n_1 \cos\theta_0}\right)$$

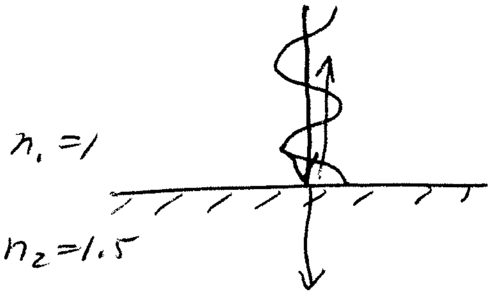
NORMAL INCIDENCE

$$\theta_0 = \theta_t = 0 \implies \cos\theta_0 = \cos\theta_t = 1$$



$$r_{TE} = \frac{n_1 - n_2}{n_1 + n_2}$$

$$r_{TM} = \frac{n_2 - n_1}{n_2 + n_1} = -r_{TE}$$



RARE TO DENSE $n_1 = 1$

$n_2 = 1.5$

$$r_{TE} = \frac{1 - 1.5}{1 + 1.5} = -0.2 = 0.2 \cdot e^{+i\pi}$$

$r_{TM} = +0.2$ $\quad R_{TE} = R_{TM} = (0.2)^2 = 4\%$

NORMAL INCIDENCE

$$t_{TE} = \frac{2n_1}{n_1 + n_2} = \frac{2 \cdot 1}{2.5} = 0.8$$

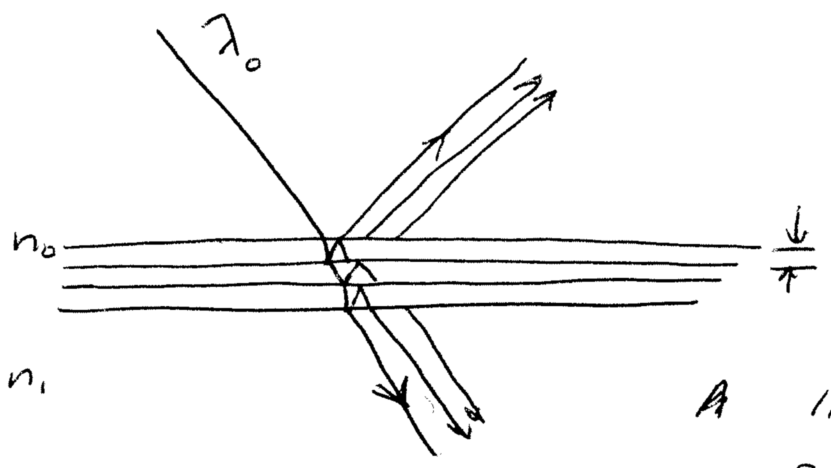
$$t_{Tm} = \frac{2n_1}{n_1 + n_2} = 0.8$$

$$T = t^2 \cdot \frac{n_2}{n_1} = 0.64 \cdot 1.5 = 0.96 = 1 - R$$

DENSE TO RARE $n_1 = 1.5$ $n_2 = 1.0$

$r_{TE} = +0.2$ $r_{Tm} = -0.2$ $R_{TE} = R_{Tm} = 0.04$

$T_{Tm} = T_{TE} = 0.96$



A IF PHASES OF TRANSMITTED RAYS "MATCH" ⇒ MORE TRANSMITTED LIGHT

ANTI-REFLECTION COATING - AR COAT

BREWSTER'S ANGLE $r_{TM} = 0 \Rightarrow R_{TM} = 0 \Rightarrow$ ~~$R_{TE} = 1/2$~~

$T_{TM} = 1$

$$r_{TM} = \frac{n_2 \cos\theta_0 - n_1 \cos\theta_t}{n_2 \cos\theta_0 + n_1 \cos\theta_t} = 0$$

SNELL'S LAW

$$n_2 \cos\theta_0 = n_1 \cos\theta_t$$

$$n_1 \sin\theta_0 = n_2 \sin\theta_t$$

$\boxed{r_{TM} = 0} \Rightarrow \theta_0 = \theta_B$ = BREWSTER'S ANGLE

$$n_2^2 \cos^2\theta_0 = n_1^2 \cos^2\theta_t \Rightarrow \cos^2\theta_t = \left(\frac{n_2}{n_1}\right)^2 \cos^2\theta_0$$

$$n_1^2 \sin^2\theta_0 = n_2^2 \sin^2\theta_t \Rightarrow \underline{\sin^2\theta_t = \left(\frac{n_1}{n_2}\right)^2 \sin^2\theta_0}$$

$$\cos^2\theta_t + \sin^2\theta_t = 1 = \cos^2\theta_0 + \sin^2\theta_0 = \left(\frac{n_2}{n_1}\right)^2 \cos^2\theta_0 + \left(\frac{n_1}{n_2}\right)^2 \sin^2\theta_0$$

DEFINE $\theta_0 = \theta_B$ IF $r_{TM} = 0$

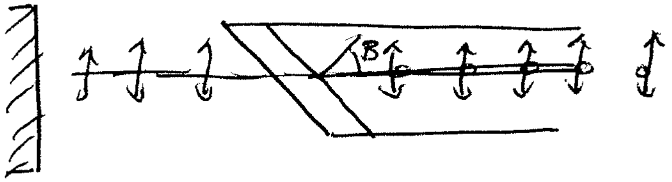
$$\cos^2\theta_B - \left(\frac{n_2}{n_1}\right)^2 \cos^2\theta_B = \left(\frac{n_1}{n_2}\right)^2 \sin^2\theta_B - \sin^2\theta_B$$

$$\cos^2\theta_B \left(1 - \left(\frac{n_2}{n_1}\right)^2\right) = \sin^2\theta_B \left(\left(\frac{n_1}{n_2}\right)^2 - 1\right)$$

$$\cos^2\theta_B \left(\frac{\cancel{n_1^2 - n_2^2}}{n_1^2}\right) = \sin^2\theta_B \left(\frac{\cancel{n_1^2 - n_2^2}}{n_2^2}\right)$$

$$\frac{\sin^2\theta_B}{\cos^2\theta_P} = \left(\frac{n_2}{n_1}\right)^2 \Rightarrow \tan\theta_B = \frac{n_2}{n_1} \Rightarrow \theta_B = \tan^{-1}\left(\frac{n_2}{n_1}\right)$$

θ_B IF $n_1 = 1$, $n_2 = 1.5$



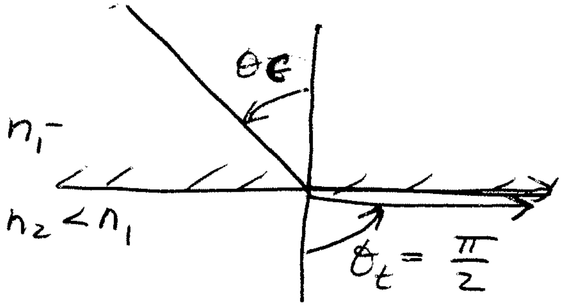
$$\theta_B = \mathrm{TAN}^{-1}(1.5) = 56.3^\circ$$

$$\theta_B = \mathrm{TAN}^{-1}\left(\frac{1}{1.5}\right) \simeq 36^\circ$$

CRITICAL ANGLE

DENSE TO RARE

$$r_{TM} = \frac{n_2 \cos\theta_0 - n_1 \cos\theta_t}{n_2 \cos\theta_0 + n_1 \cos\theta_t}$$



$$\theta_t = \frac{\pi}{2} \Rightarrow \cos\theta_t = 0$$

$$r_{TM} = \frac{n_2 \cos\theta_0}{n_2 \cos\theta_0} = 1$$

$$n_1 \sin\underset{\underset{c}{\uparrow}}{\theta_0} = n_2 \sin\theta_t = n_2 \cdot 1$$

$$n_1 \sin\theta_c = n_2 \Rightarrow \theta_c = \sin^{-1}\left(\frac{n_2}{n_1}\right)$$

BREWSTER'S ANGLE $\theta_B = TAN^{-1}\left(\frac{n_2}{n_1}\right)$

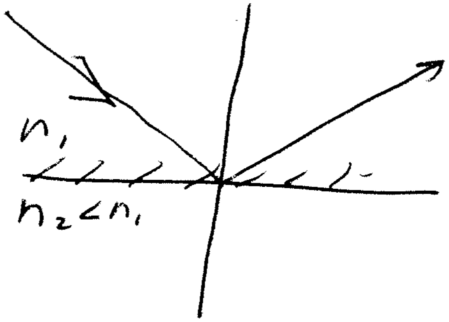
(DENSE-TO-RARE AND RARE-TO-DENSE)

CRITICAL ANGLE $\theta_C = SIN^{-1}\left(\frac{n_2}{n_1}\right)$

~~RA~~ DENSE-TO-RARE ⇒ ~~TOTAL~~ NO TRANSMITTED r_{TM}

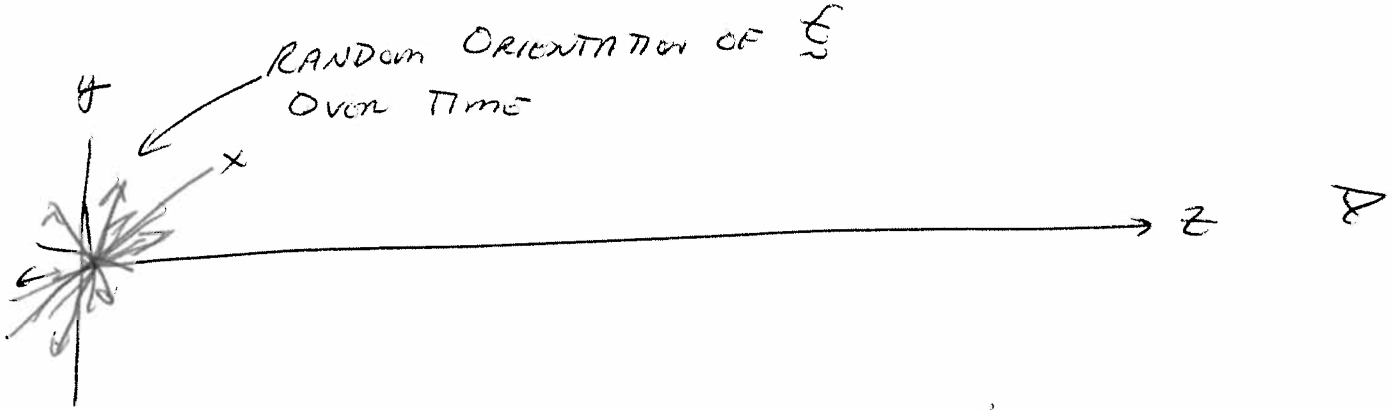
⇒ 100% REFLECTANCE

⇒ TOTAL INTERNAL REFLECTION

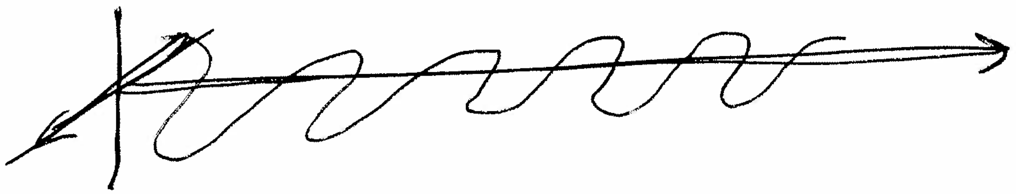


POLARIZED LIGHT

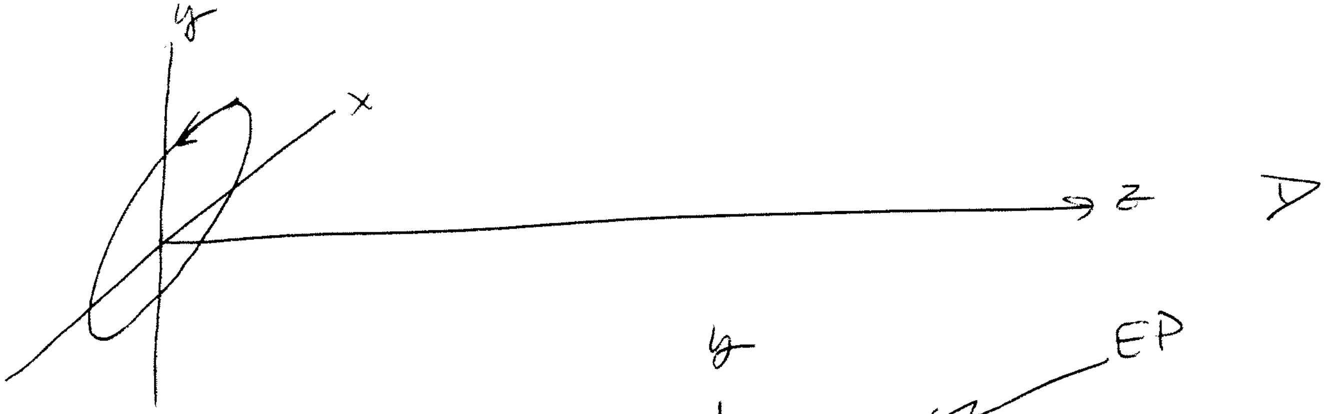
DOMINANT ~~STATE~~ ORIENTATION OF E VECTOR

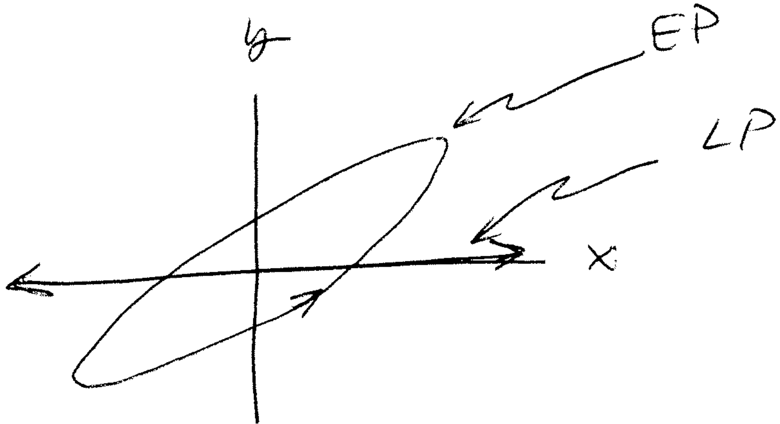


UNPOLARIZED LIGHT ⇒ NATURAL LIGHT



LINEAR POLARIZATION
= PLANE POLARIZATION





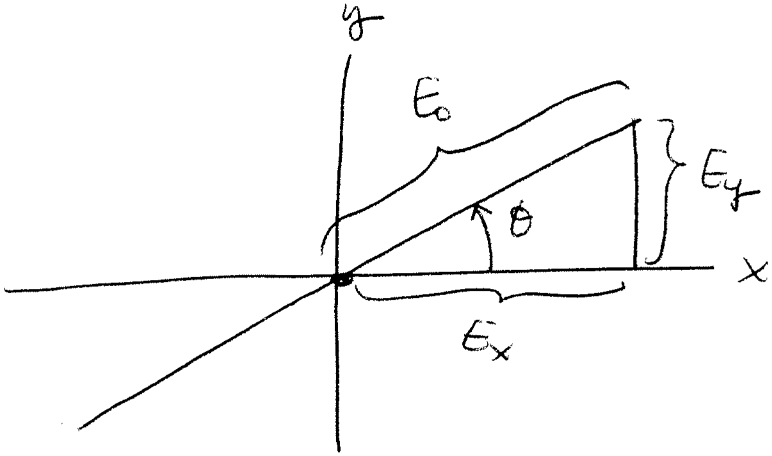
PLANE WAVE

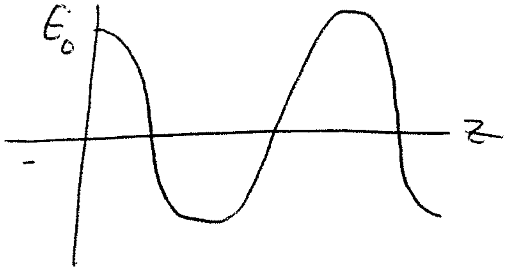
PROPAGATE DOWN Z $\Longrightarrow$ OSCILLATING IN x AND/OR y

$$\underset{\sim}{E}[x,y,z,t] = \left(\hat{\underset{\sim}{x}}\, E_x + \hat{\underset{\sim}{y}}\, E_y\right) \cos\left(k_0 z - \omega_0 t + \underset{\substack{\uparrow \\ \text{IGNORE}}}{\varphi_0}\right)$$

$$= \left(\hat{\underset{\sim}{x}}\, E_x + \hat{\underset{\sim}{y}}\, E_y\right) \cos\left(2\pi\left(\frac{z}{\lambda_0} - \nu_0 t\right) + \varphi_0\right)$$

LP $\hat{\underset{\sim}{x}}\, E_x + \hat{\underset{\sim}{y}}\, E_y$ IN SAME PLANE





$$\left.\begin{aligned} E_x &= E_0 \cos\theta \\ E_y &= E_0 \sin\theta \end{aligned}\right\} \ \theta = \text{"ANGLE OF POLARIZATION"}$$

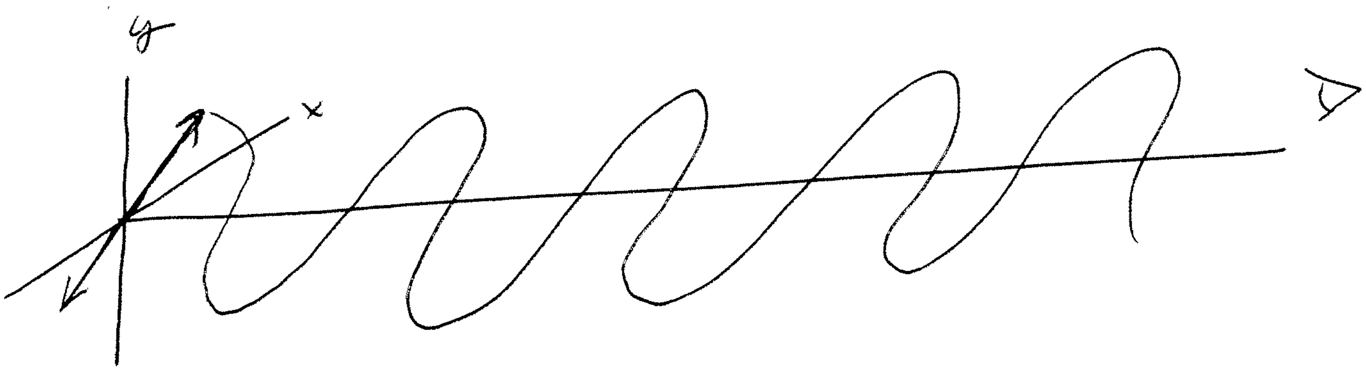
$$= \text{TAN}^{-1}\left[\frac{E_y}{E_x}\right]$$

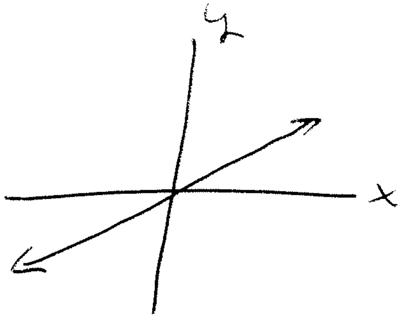
E_x AND E_y ARE "IN PHASE"

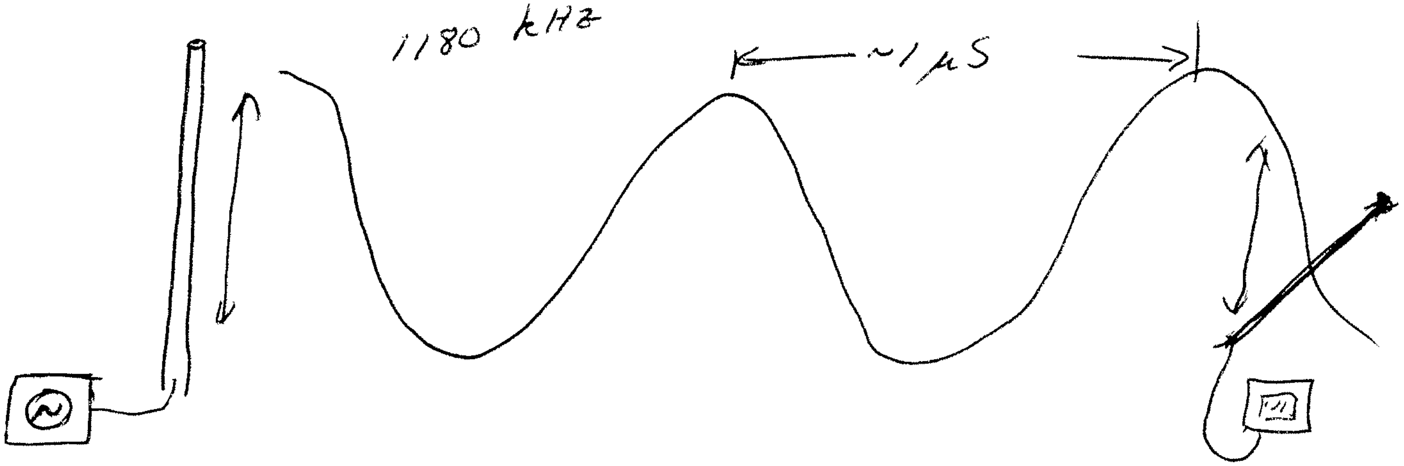
GENERATION OF LP

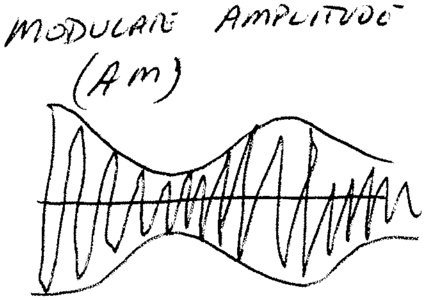
(1) CONSTRAIN ELECTRON DIRECTION OF MOTION AT SOURCE

("SELECTIVE EMISSION")









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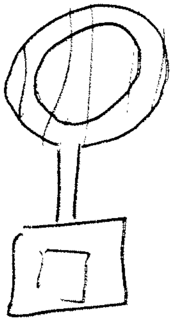
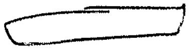


TOP VIEW

POLARIZED "LIGHT"

EDGE

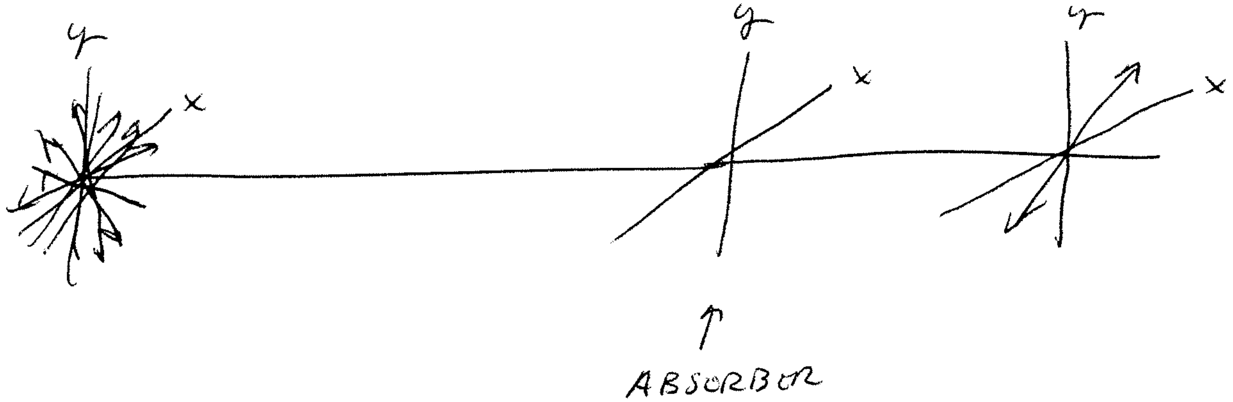


LITTLE SIGNAL

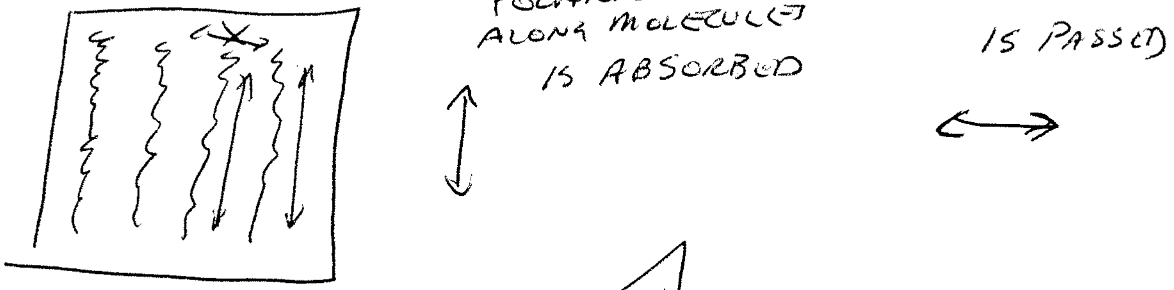
FACE

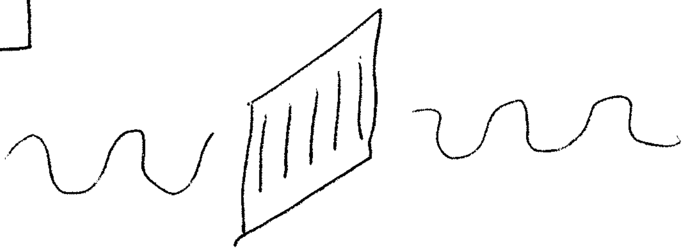
MORE SIGNAL

② SELECTIVE ABSORPTION



EDWIN LAND → POLAROID





③ SELECTIVE REFLECTION

BREWSTER'S ANGLE

$r_{TM} = 0$ AT BREWSTER'S ANGE

ONLY TE IS REFLECTED

④ POLARIZATION BY SCATTERING - DIPOLE RADIATION