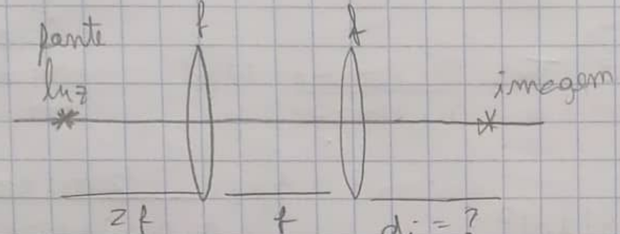
b) $\frac{\lambda}{4}$ @ $45°$ $\begin{bmatrix} \cos^2\theta + i\,\text{sen}^2\theta & (1-i)\cos\theta\,\text{sen}\theta \\ (1-i)\cos\theta\,\text{sen}\theta & i\cos^2\theta + \text{sen}^2\theta \end{bmatrix} \rightarrow \frac{1}{2}\begin{bmatrix} 1+i & 1-i \\ 1-i & 1+i \end{bmatrix}$

$$\begin{bmatrix} 0 & 0 \\ 0 & 1 \end{bmatrix} \underbrace{\frac{1}{2}\begin{bmatrix} 1+i & 1-i \\ 1-i & 1+i \end{bmatrix}\begin{bmatrix} 1 \\ 0 \end{bmatrix}}_{\frac{1}{2}\begin{bmatrix} 1+i \\ 1-i \end{bmatrix}} = \frac{1}{2}\begin{bmatrix} 0 \\ 1-i \end{bmatrix} = \vec{V}$$

$$\sqrt{|\vec{V}|^2} = \sqrt{\frac{1}{4}(1^2+1^2)} = \frac{1}{\sqrt{2}}$$

6)



$$\begin{array}{ccccc} \text{propag. } d_i & 2^{\text{a}} \text{ lente} & \text{dist } f & 1^{\text{a}} \text{ lente} & \text{propagação } 2f \\ \begin{bmatrix} 1 & d_i \\ 0 & 1 \end{bmatrix} & \begin{bmatrix} 1 & 0 \\ -1/f & 1 \end{bmatrix} & \begin{bmatrix} 1 & f \\ 0 & 1 \end{bmatrix} & \begin{bmatrix} 1 & 0 \\ -1/f & 1 \end{bmatrix} & \begin{bmatrix} 1 & 2f \\ 0 & 1 \end{bmatrix} \end{array}$$

a)

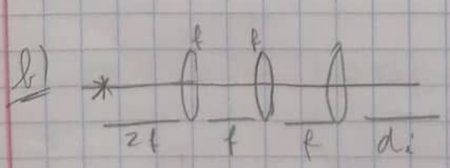
$$\begin{bmatrix} 1 & d_i \\ 0 & 1 \end{bmatrix} \underbrace{\begin{bmatrix} 1 & 0 \\ -1/f & 1 \end{bmatrix}\begin{bmatrix} 1 & f \\ 0 & 1 \end{bmatrix}}_{\begin{bmatrix} 1 & f \\ -1/f & 0 \end{bmatrix}} \underbrace{\begin{bmatrix} 1 & 0 \\ -1/f & 1 \end{bmatrix}\begin{bmatrix} 1 & 2f \\ 0 & 1 \end{bmatrix}}_{\begin{bmatrix} 1 & 2f \\ -1/f & -1 \end{bmatrix}}$$

$$\begin{bmatrix} 1 & d_i \\ 0 & 1 \end{bmatrix}\begin{bmatrix} 0 & f \\ -1/f & -2 \end{bmatrix} = \begin{bmatrix} -d_i/f & f - 2d_i \\ -1/f & -2 \end{bmatrix}$$

condição do plano conjugado

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} \Rightarrow B = 0 \Rightarrow f - 2d_i = 0 \Leftrightarrow d_i = \frac{f}{2}$$

b)



já foi calculado $\rightarrow \begin{bmatrix} 0 & f \\ -1/f & -2 \end{bmatrix}$

$$\begin{bmatrix} 1 & d_i \\ 0 & 1 \end{bmatrix} \underbrace{\underbrace{\begin{bmatrix} 1 & 0 \\ -1/f & 1 \end{bmatrix}\begin{bmatrix} 1 & f \\ 0 & 1 \end{bmatrix}}_{\begin{bmatrix} 1 & f \\ -1/f & 0 \end{bmatrix}} \begin{bmatrix} 0 & f \\ -1/f & -2 \end{bmatrix}}_{\begin{bmatrix} -1 & -f \\ 0 & -1 \end{bmatrix}} = \begin{bmatrix} -1 & -f-d_i \\ 0 & -1 \end{bmatrix}$$

$B = -f - d_i = 0$

$d_i = -f$ //

a) $x(t) = \frac{e}{2\omega_0 m}\left[\frac{1}{\Delta\omega + i\cancel{\gamma}^{0}}\right] E_0\, e^{-i\omega t}$ pq é mt peq comparando e/ω_0

$\Delta\omega = \omega - \omega_0 = \frac{\omega_0}{2} - \omega_0$
$= -\frac{\omega_0}{2}$

$|x| = \frac{e E_0}{\cancel{2}\omega_0 m}\,\frac{1}{+\frac{\omega_0}{\cancel{2}}} = \frac{e E_0}{m\omega_0^2}$

$I = 100\,\frac{mW}{cm^2} = 0{,}1\,\frac{W}{m^2}\times 10^4 = 1000\,W$

$I = \frac{1}{2}\varepsilon_0 n c |E_0|^2 \rightarrow E_0 = \sqrt{\frac{2I}{\varepsilon_0 c}} = \sqrt{\frac{2000}{8{,}85\times10^{-12}\times 3\times10^{8}}} \simeq 870\ V/m$

$|x| = \frac{1{,}6\times10^{-19}\times 870\ V/m}{9{,}1\times10^{-31}\,kg\times 6\times10^{15}} = 4\times10^{-18}\,m$

b) $n(\omega) = 1 - \frac{Ne^2}{4\omega_0\varepsilon_0 m}\underbrace{\left[\frac{\Delta\omega}{\Delta\omega^2 + \cancel{\gamma^2}}\right]}_{\frac{1}{\Delta\omega} = \frac{-2}{\omega_0}} = 1 + \frac{Ne^2}{4\omega_0\varepsilon_0 m}\times\frac{2}{\omega_0} = 1 + \frac{Ne^2}{2\omega_0^2\varepsilon_0 m}$

$= 1 + \frac{10^{28}\,m^{-3}(1{,}6\times10^{-19}\,C)^2}{2\times(6\times10^{15})^2\times 8{,}85\times10^{-12}\frac{C}{V\,m}\times 9\times10^{-31}\,kg} = 1 + 0{,}44 = 1{,}44$

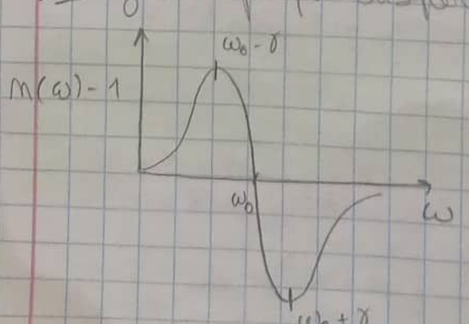
$\alpha(\omega) = \frac{Ne^2}{2\varepsilon_0 m c}\,\underbrace{\frac{\gamma}{\Delta\omega^2 + \cancel{\gamma^2}\to 0}}_{\frac{\omega_0/10^6}{\omega_0^2/4}} = \frac{Ne^2}{\omega_0\varepsilon_0 m c\times10^6} \rightarrow 35{,}4\ m^{-1}$

c) $I(z) = I_0\, e^{-\alpha z}$ $0{,}9\,\cancel{I_0} = \cancel{I_0}\, e^{-\alpha z}$

$\ln(0{,}9) = \ln[e^{-\alpha z}] = -\alpha z$

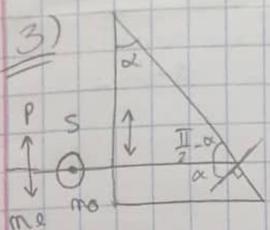
$z = \frac{-\ln(0{,}9)}{\alpha} = 3\ mm$

d) gama freqs dispersão é anómala



$\omega_0 - \gamma \leq \omega \leq \omega_0 + \gamma$

3)



$n_o = 1,66$
$n_e = 1,49$

reflexão total

$n_i \operatorname{sen}\theta_c = n_t^{\nearrow 1} \operatorname{sen} 90^\circ$

$\theta_c^o = \operatorname{sen}^{-1}\left(\frac{1}{1,66}\right) \simeq$

$\simeq 37^\circ$

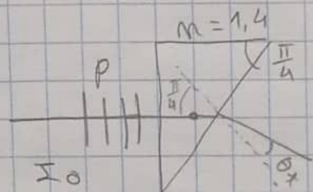
$\theta_c = \operatorname{sen}^{-1}\left(\frac{1}{n_i}\right)$

$\theta_c^e = \operatorname{sen}^{-1}\left(\frac{1}{1,49}\right) \simeq 42,1^\circ$

$37,0^\circ \rightarrow 42,1^\circ$ só o raio extraordinário é transmitido, p

NOTA: A polariz // ao eixo ótico é extraordinária

4)



$I_t = ?$

1ª $T_1 = \frac{n_t \cos\theta_t}{n_i \cos\theta_i} |t_p|$

$\theta_i = 0 = \theta_t$
$n_i = 1$
$n_t = 1,4$

$t_p = \frac{2 n_i \cos\theta_i}{n_i \cos\theta_t + n_t \cos\theta_i} =$

$T_1 = 1,4 |t_p|^2 =$

$= 1,4 \left|\frac{2}{2,4}\right|^2 \simeq 0,972$

$= \frac{2}{1+1,4}$

2ª interface snell $n_i \operatorname{sen}\theta_i = n_t \operatorname{sen}\theta_t$

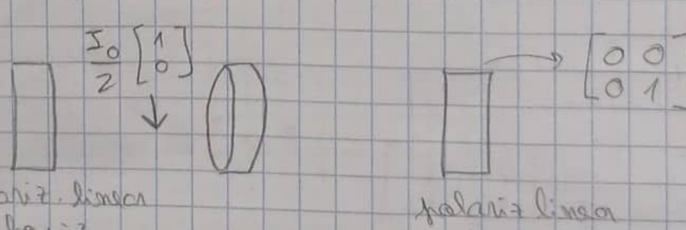
$1,4 \frac{1}{\sqrt{2}} = 1 \operatorname{sen}\theta_t \Leftrightarrow \theta_t = \operatorname{sen}^{-1}\left(\frac{1,4}{\sqrt{2}}\right) \simeq 81,87^\circ$

$t_p = \frac{2 \times (1,4)\, 1/\sqrt{2}}{1,4 \cos(81,87^\circ) + 1/\sqrt{2}} = 2,18$

$T_2 = \frac{\cos(81,87^\circ)}{1,4\ (1/\sqrt{2})} |2,18|^2 = 0,68$

$T_{tot} = T_1 \times T_2 = 0,97 \times 0,68 \simeq 0,66$

5) luz n polariz

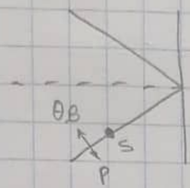


a) $\frac{\lambda}{2}$ $\theta = \theta$ $\quad 2\theta = 90^\circ$ $\begin{bmatrix}\cos 2\theta & \operatorname{sen} 2\theta \\ \operatorname{sen} 2\theta & -\cos 2\theta\end{bmatrix} \rightarrow \begin{bmatrix}0&1\\1&0\end{bmatrix}$

$\begin{bmatrix}0&0\\0&1\end{bmatrix}\begin{bmatrix}0&1\\1&0\end{bmatrix}\begin{bmatrix}1\\0\end{bmatrix} = \begin{bmatrix}0&0\\0&1\end{bmatrix}\begin{bmatrix}0\\1\end{bmatrix} = \begin{bmatrix}0\\1\end{bmatrix} \Rightarrow \frac{I_0}{2}$

RESOLUÇÃO TESTE

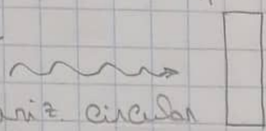
A)



p 100% transmitida

B)

polarizador linear θ



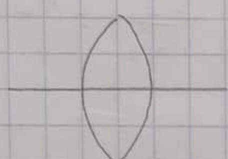
polariz. circular mão direita

$$\begin{bmatrix} \cos^2\theta & \sin\theta\cos\theta \\ \sin\theta\cos\theta & \sin^2\theta \end{bmatrix} \frac{1}{\sqrt{2}} \begin{bmatrix} 1 \\ -i \end{bmatrix} =$$

$$= \frac{1}{\sqrt{2}} \begin{bmatrix} \cos\theta\,(\cos\theta - i\sin\theta) \\ \sin\theta\,(\cos\theta - i\sin\theta) \end{bmatrix} = \frac{e^{-i\theta}}{\sqrt{2}} \begin{bmatrix} \cos\theta \\ \sin\theta \end{bmatrix}$$

$$|\vec{V}|^2 = \frac{\overbrace{e^{-i\theta} e^{i\theta}}^{1}}{2} \left[\cos^2\theta + \sin^2\theta\right] = \frac{1}{2}$$

C)



$R_1 > 0$
$R_2 < 0$

$$\frac{1}{f} = (n_{lente} - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

$|R_2| = 2|R_1|$

$|R_1| = ?$

$n_{lente} = 1{,}52$

$f = 50\ mm$

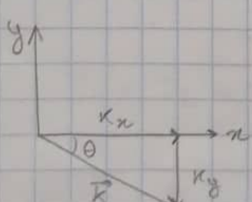
$$(\Leftrightarrow) \frac{1}{50mm} = (1{,}52 - 1)\underbrace{\left[\frac{1}{R_1} + \frac{1}{2R_1}\right]}_{\frac{3}{2}R_1}$$

$$(\Leftrightarrow) R_1 = 50 \times 0{,}52 \times \frac{3}{2} =$$

$$= 39\ mm$$

1) $E(\vec{r},t) = \left(3500\,\frac{V}{m}\right)\hat{z}\ \sin\left\{\underbrace{(2{,}5\times10^6\ m^{-1})}_{K_x} x - \underbrace{(10^6\ m^{-1})}_{K_y} y - \omega t + \frac{3\pi}{2}\right\}$

a)



$$\tan\theta = \frac{-\cancel{10^6}\ m^{-1}}{2{,}5\times\cancel{10^6}\ m^{-1}} \quad (\Leftrightarrow) \theta = \tan^{-1}\left(\frac{-1}{2{,}5}\right) \simeq -21{,}0°$$

b) $|\vec{B}| = \frac{|\vec{E}|}{c} = \frac{3500}{3\times10^8} = 1{,}17\times10^{-5}\ T = 11{,}7\ \mu T$

$f = ?$ $\quad f = \frac{c}{\lambda} = \frac{c|\vec{K}|}{2\pi} = \frac{3\times10^8}{2\pi}\times10^6\sqrt{(2{,}5^2+1^2)} \simeq 1{,}28\times10^{14}\ Hz$

2) Lorentz

$\omega_0 = 6\times10^{15}\ r/s$

$\gamma = 6\times10^9 = \frac{\omega_0}{10^6}\ r/s$

$\lambda = 628\ nm$

$$\omega = 2\pi\frac{c}{\lambda} = \frac{\cancel{2\pi}\times3\times10^8}{\cancel{628}\times10^{-9}} =$$

$$= 3\times10^{15} = \frac{\omega_0}{2}$$

4)