Oblique incidence Tx/Rx example

(1) parallel or perpendicular polarization? OR both? ⇒ sketch

(2) θ_i, θ_r; θ_t ⇒ Snell's Law

(3) $\Gamma_{\parallel}, T_{\parallel}$ or $\Gamma_{\perp}, T_{\perp}$

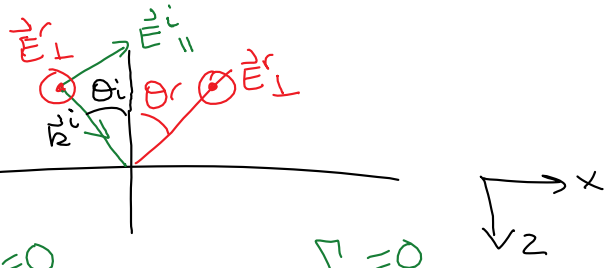
(4) $\vec{E}^r$ → propagate away from interface ($\vec{k}_r$)
→ $\Gamma_{\parallel}$ or $\Gamma_{\perp}$
$\vec{E}^t$ → change material ($\vec{k}_t$) & θ_t
→ $T_{\parallel}$ or $T_{\perp}$

⇒ Brewster angle: $T_{\parallel} = 1$, $\Gamma_{\parallel} = 0$; $\theta_B = \tan^{-1}\left(\sqrt{\epsilon_{R2}/\epsilon_{R1}}\right)$

Ex unpolarized laser beam is incident on the interface between glass and air

(1) glass
$\epsilon_R = 2.25$
μ_0
$\sigma = 0$

(2) air
ϵ_0, μ_0



$\vec{E}^i = [9\cos\theta_i \vec{a}_x + 4\vec{a}_y - 9\sin\theta_i \vec{a}_z) e^{-j7(x\sin\theta_i + z\cos\theta_i)}]$

($\vec{a}_x$: $\parallel$, $\Gamma_{\parallel}=0$; $4\vec{a}_y$: $\perp$; $\vec{a}_z$: $\parallel$, $\Gamma_{\parallel}=0$)

Find θ_i to give reflected laser beam with $\vec{E}^r$ totally perpendicularly polarized.

⇒ $\theta_i = \theta_B$ $\quad \theta_B = \tan^{-1}\left(\sqrt{\frac{\epsilon_{R2}}{\epsilon_{R1}}}\right)$

$\theta_B = 33.7°$

$\vec{E}^r = ?$ → $\Gamma_{\perp}$ → $\eta_1 = 251.33\,\Omega$
$\eta_2 = 120\pi\,\Omega$
↘ θ_i
θ_t → Snell's law $\quad \frac{\sin\theta_t}{\sin\theta_i} = \sqrt{\frac{\epsilon_{R1}}{\epsilon_{R2}}}$

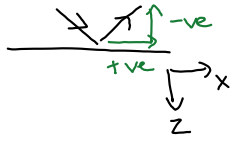
↳ $\theta_t = 56.3°$

$$\Gamma_{\perp} = \frac{\eta_2\cos\theta_i - \eta_1\cos\theta_t}{\eta_2\cos\theta_i + \eta_1\cos\theta_t}$$

$$= 0.385$$

$\vec{E}^r \Rightarrow \vec{E}^i_\perp = (4\hat{a}_y)(e^{-j7(x\sin\theta_i + z\cos\theta_i)})$

$\vec{E}^r = (4)(0.385)e^{-j7(x\sin\theta_i - z\cos\theta_i)}\hat{a}_y$



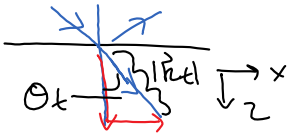
$\vec{E}^t \Rightarrow$ $T_{||}$ $|\vec{k}_t| = \omega\sqrt{\mu_0\epsilon_0}$ (*) $1+\Gamma_{||} = T_{||}\left(\frac{\cos\theta_t}{\cos\theta_i}\right)$

$T_\perp$ $\vec{k}_t$ $T_{||} = 1.51$, $T_\perp = 1.38$

$\vec{E}^t = \vec{E}^t_{||} + \vec{E}_\perp \rightarrow |\vec{k}_i| = \omega\sqrt{\mu_0\epsilon_0(2.25)} = 7$

$|\vec{k}_t| = \omega\sqrt{\mu_0\epsilon_0}$

$\frac{|\vec{k}_t|}{|k_i|} = \frac{1}{\sqrt{2.25}} \Rightarrow |\vec{k}_t| = \frac{7}{\sqrt{2.25}} = 4.67$ rad/m



$\vec{E}^t_\perp = (4)(1.38)e^{-j4.67(x\sin\theta_t + z\cos\theta_t)}\hat{a}_y$ ($T_\perp$, $|\vec{k}_t|$)

$\vec{E}^i_{||} = (9\cos\theta_i\hat{a}_x - 9\sin\theta_i\hat{a}_z)e^{-j7(x\sin\theta_i + z\cos\theta_i)}$

$\vec{E}^t_{||} = (9)(1.51)[\cos\theta_t\hat{a}_x - \sin\theta_t\hat{a}_z]e^{-j4.67(x\sin\theta_t + z\cos\theta_t)}$