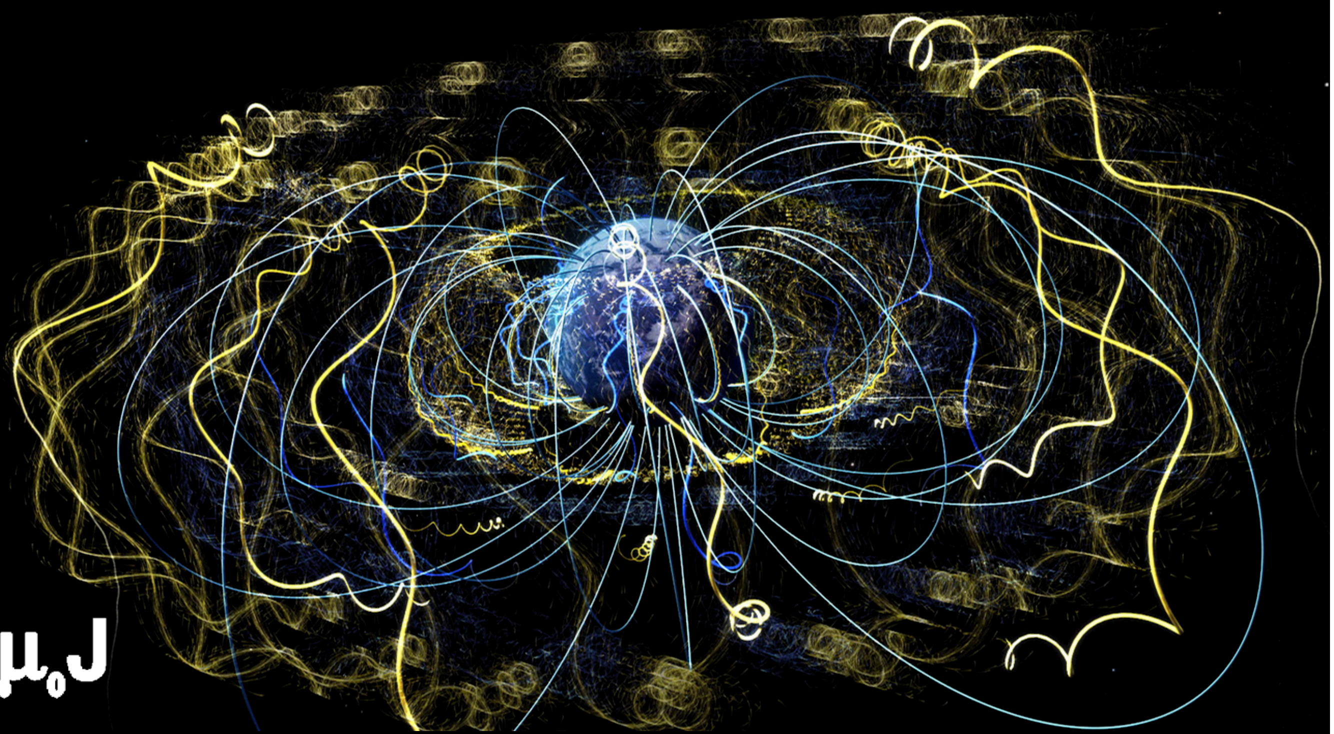
$$\nabla \cdot \mathbf{E} = \frac{\rho}{\varepsilon_0}$$

$$\nabla \cdot \mathbf{B} = 0$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

$$\nabla \times \mathbf{B} = \mu_0 \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t} + \mu_0 \mathbf{J}$$



Electricity and Magnetism II: 3812

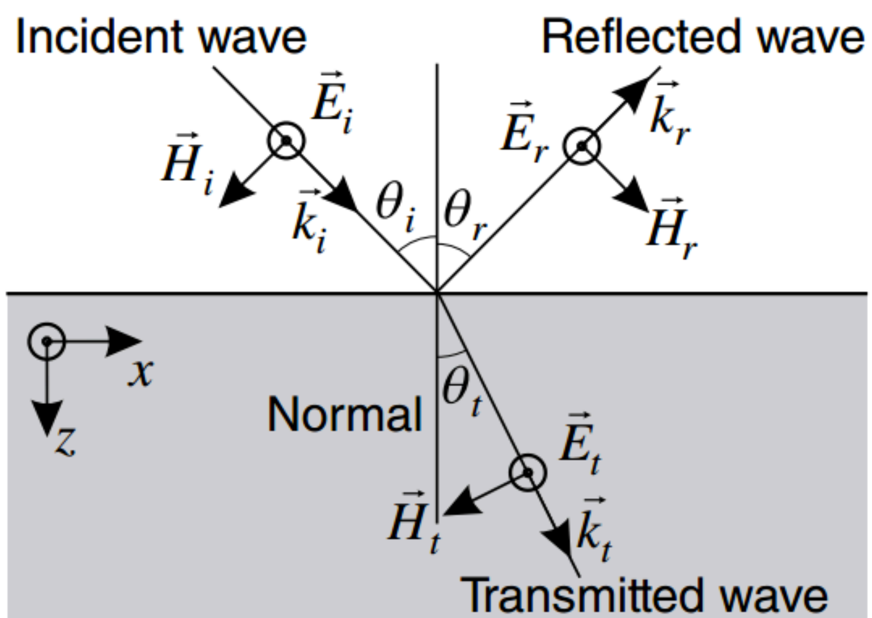
Professor Jasper Halekas
Van Allen 70
MWF 9:30-10:20 Lecture

Reflection & Transmission at Oblique Incidence

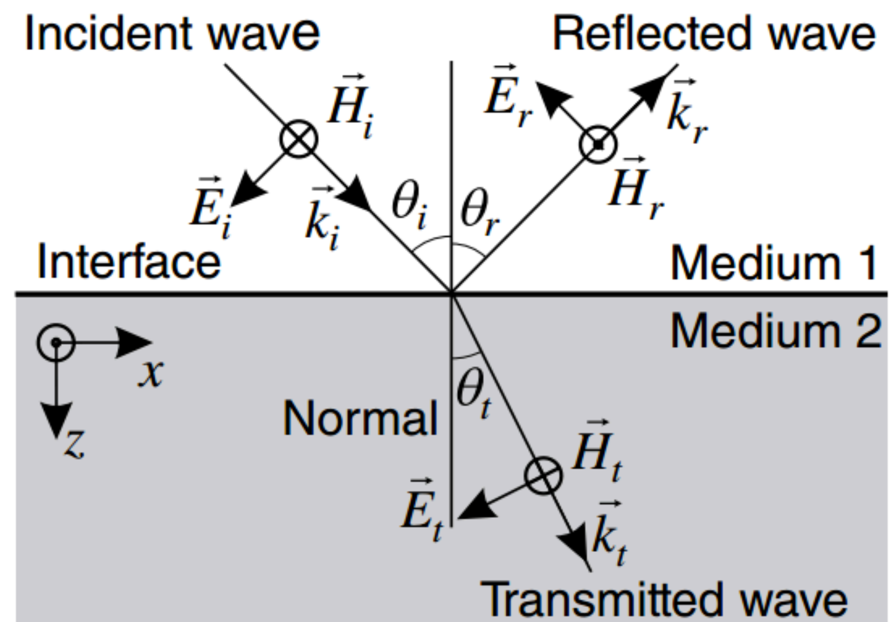
Out-of-Plane (S) Polarization

In-Plane (P) Polarization

1.



2.



Transmission / Reflection

For in-plane polarization (P)
$\vec{E}$ in incidence plane
$\vec{B}$ normal to incidence plane

$\Delta \vec{E}_{\parallel} = 0 \Rightarrow \tilde{E}_{0Ix} + \tilde{E}_{0Rx} = \tilde{E}_{0Tx}$

$\Delta D_{\perp} = 0 \Rightarrow \varepsilon_1 \tilde{E}_{0Iz} + \varepsilon_1 \tilde{E}_{0Rz} = \varepsilon_2 \tilde{E}_{0Tz}$

$$\Delta \vec{H}_{\parallel} = 0 \Rightarrow \frac{\tilde{B}_{0Iy}}{\mu_1} + \frac{\tilde{B}_{0Ry}}{\mu_1} = \frac{\tilde{B}_{0Ty}}{\mu_2}$$

$$\Rightarrow \tilde{E}_{0I} \cos\theta_I + \tilde{E}_{0R} \cos\theta_R = \tilde{E}_{0T} \cos\theta_T$$

(note $\vec{E} \perp \vec{k}$!)

$$\varepsilon_1 \left(\tilde{E}_{0I} \sin\theta_I - \tilde{E}_{0R} \sin\theta_R \right) = \varepsilon_2 \tilde{E}_{0T} \sin\theta_T$$

$$\frac{1}{\mu_1 v_1} \left(\tilde{E}_{0I} - \tilde{E}_{0R} \right) = \frac{1}{\mu_2 v_2} \tilde{E}_{0T}$$

Define $\beta = \frac{\mu_1 v_1}{\mu_2 v_2} = \frac{\mu_1 n_2}{\mu_2 n_1}$

$\alpha = \cos\theta_T / \cos\theta_I$

$$\Rightarrow \boxed{\tilde{E}_{0R} = \left(\frac{\alpha - \beta}{\alpha + \beta} \right) \tilde{E}_{0I} \qquad \tilde{E}_{0T} = \frac{2}{\alpha + \beta} \tilde{E}_{0I}}$$

$\alpha = 1$
$\rightarrow$ normal incidence

For out-of-plane polarization (s)

$\vec{E} \perp$ incidence plane

$\vec{B}$ in incidence plane

$$\Rightarrow \boxed{\begin{aligned} \tilde{E}_{0R} &= \frac{1-\alpha\beta}{1+\alpha\beta}\tilde{E}_{0I} \\ \tilde{E}_{0T} &= \frac{2}{1+\alpha\beta}\tilde{E}_{0I} \end{aligned}}$$

$\alpha = 1$
$\rightarrow$ normal incidence

Energy flux through surface

$$\vec{S}\cdot\hat{z} = S\cos\theta$$

$$\Rightarrow I_I = \frac{1}{2}\epsilon_1 v_1 E_{0I}^2 \cos\theta_I$$

$$I_R = \frac{1}{2}\epsilon_1 v_1 E_{0R}^2 \cos\theta_R$$

$$I_T = \frac{1}{2}\epsilon_2 v_2 E_{0T}^2 \cos\theta_T$$

$$\Rightarrow \boxed{\begin{aligned} R_p &= \left(\frac{\alpha-\beta}{\alpha+\beta}\right)^2 & R_s &= \left(\frac{1-\alpha\beta}{1+\alpha\beta}\right)^2 \\ T_p &= \alpha\beta\left(\frac{2}{\alpha+\beta}\right)^2 & T_s &= \alpha\beta\left(\frac{2}{1+\alpha\beta}\right)^2 \end{aligned}}$$

$$\alpha = \frac{\cos\theta_T}{\cos\theta_I} = \frac{\sqrt{1-\sin^2\theta_T}}{\cos\theta_I}$$

$$= \frac{\sqrt{1-\frac{n_1^2}{n_2^2}\sin^2\theta_I}}{\cos\theta_I}$$

Glancing Incidence

$\theta_I \to \pi/2 \Rightarrow \alpha \to \infty$

$\Rightarrow \tilde{E}_{0T} \to 0$

Total Internal Reflection

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

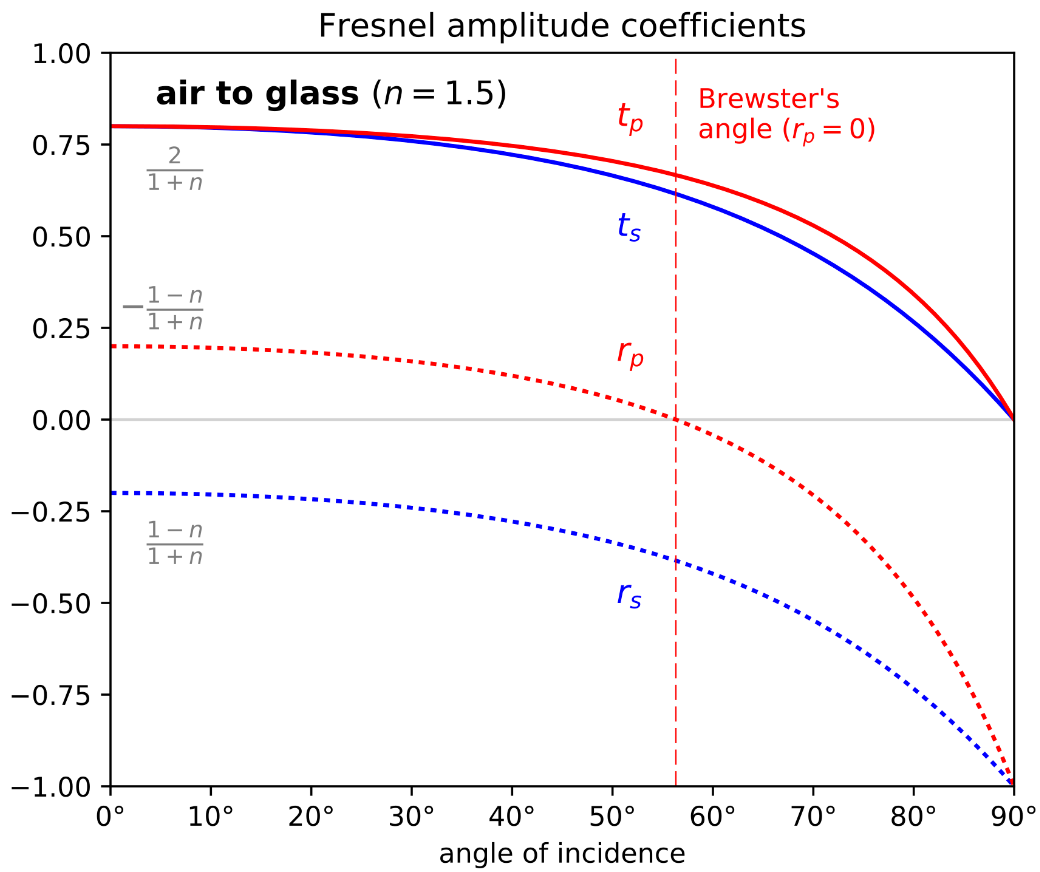
Brewsters Angle

$\tilde{E}_{0R} \to 0$ for plane-polarized at $\alpha \to \beta$

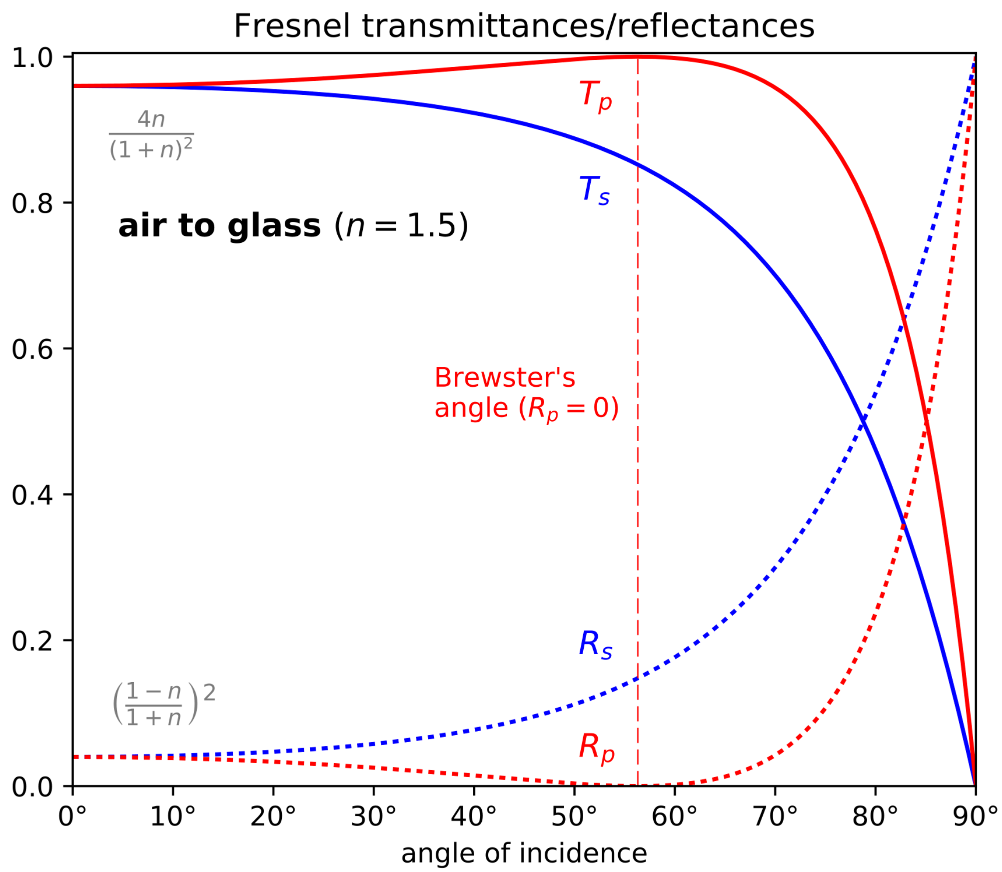
$\Rightarrow$ reflected light all perpendicularly polarized (i.e. parallel to discontinuity surface)

Polarized sunglasses block this component

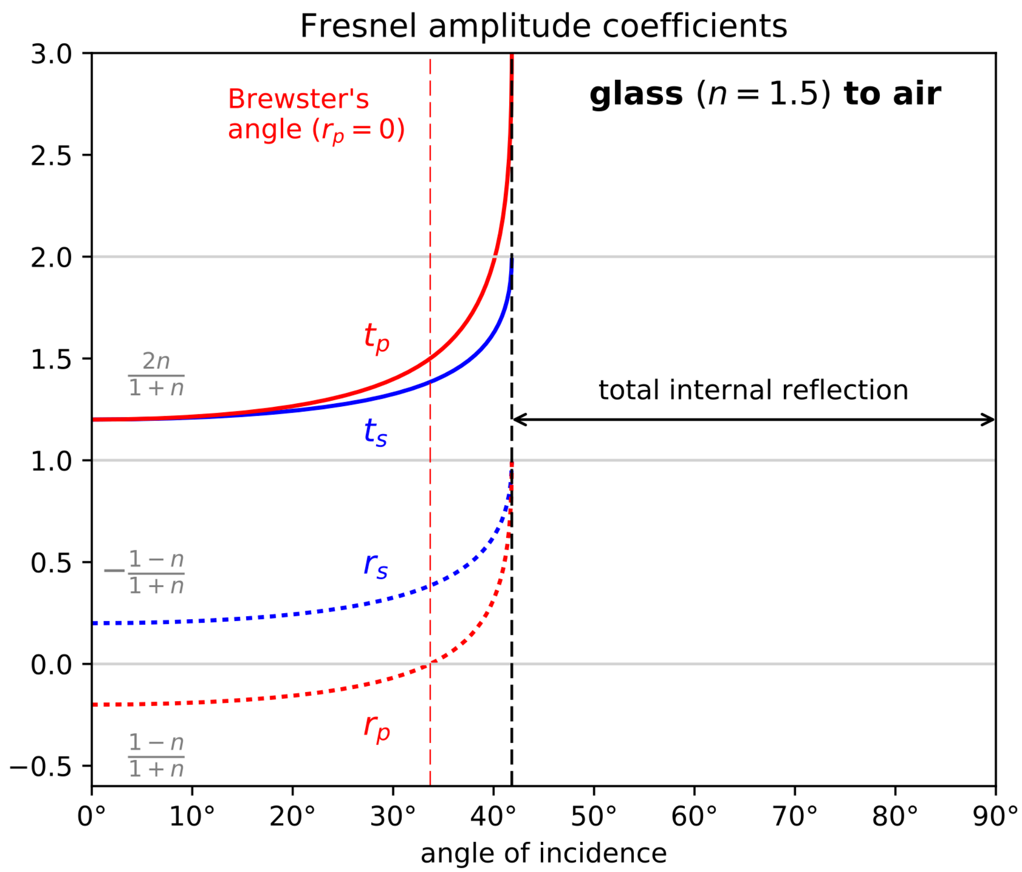
Fresnel Amplitudes ($n_2 > n_1$)



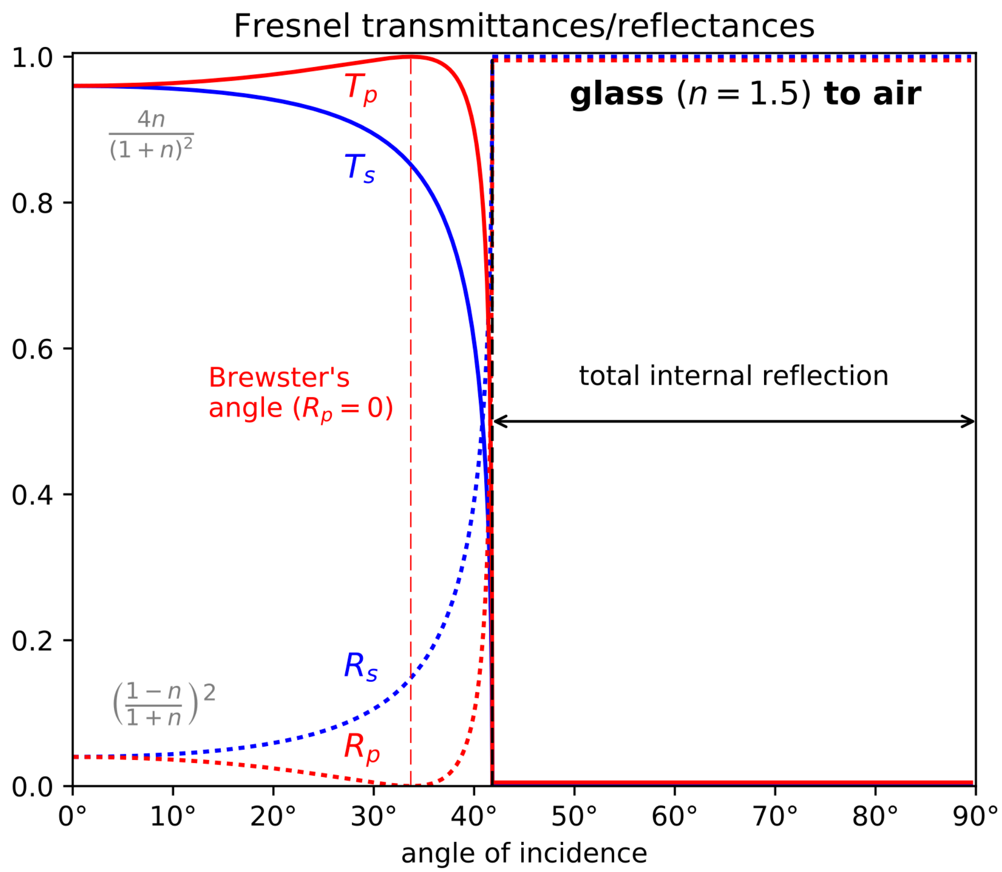
Transmission/Reflection ($n_2 > n_1$)



Fresnel Amplitudes ($n_2 < n_1$)



Transmission/Reflection ($n_2 < n_1$)



9.4 | Absorption & Dispersion

Waves in Conductors

$\rho_f, \vec{J}_f \neq 0$

still assume linear & homogeneous material

Ohm's Law $\quad \vec{J}_f = \sigma \vec{E}$

Continuity $\quad \nabla \cdot \vec{J}_f = -\partial \rho_f / \partial t$

$$\Rightarrow \partial \rho_f / \partial t = -\nabla \cdot (\sigma \vec{E})$$
$$= -\sigma \nabla \cdot \vec{E}$$
$$= -\sigma/\varepsilon \, \nabla \cdot \vec{D}$$
$$= -\sigma/\varepsilon \, \rho_f$$

$$\Rightarrow \rho_f = \rho_f(0) \, e^{-\sigma/\varepsilon \, t}$$

σ large $\Rightarrow$ ρ_f dissipates quickly

$\Rightarrow$ Maxwells Eqs.

$$\nabla \cdot \vec{E} = 0 \qquad \nabla \times \vec{E} = -\partial \vec{B} / \partial t$$
$$\nabla \cdot \vec{B} = 0 \qquad \nabla \times \vec{B} = \mu \varepsilon \, \partial \vec{E} / \partial t + \mu \vec{J}_f$$
$$= \mu \varepsilon \, \partial \vec{E} / \partial t + \mu \sigma \vec{E}$$