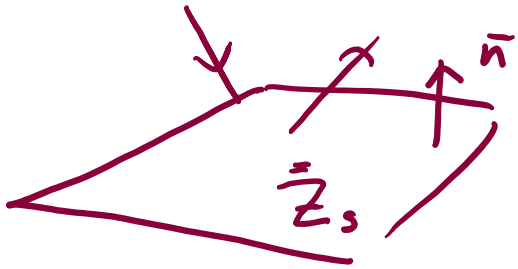
$$\bar n \cdot \bar{\bar Z}_s = \bar{\bar Z}_s \cdot \bar n = 0$$



$$(\bar u, \bar v, \bar n)$$

$$\bar{\bar I}_t = \bar u \bar u + \bar v \bar v$$

$$\bar{\bar J} = \bar n \times \bar{\bar I} = \bar n \times \bar{\bar I}_t = \bar v \bar u - \bar u \bar v$$

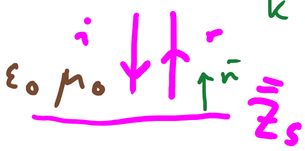
$$\bar{\bar K} = \bar u \bar u - \bar v \bar v$$

$$\bar{\bar L} = \bar u \bar v + \bar v \bar u$$

$$\left(\bar{\bar I} = \bar u \bar u + \bar v \bar v + \bar n \bar n\right)$$

$$\bar{\bar R}$$

(1)



$\bar k^i = -\bar n k_0$

$\bar k^r = +\bar n k_0$

$$\underbrace{\bar E_t}_{\bar E_t^i + \bar E_t^r} = \bar{\bar Z}_s \cdot \bar n \times \underbrace{\bar H_t}_{\bar H_t^i + \bar H_t^r}$$

$$\bar E^r = \bar{\bar R} \cdot \bar E^i$$

$$\bar{\bar R} = ?$$

$$\bar H \overset{?}{=} f(\bar E)$$

$$\bar E^i(\bar r) = \bar E^i e^{-j \bar k^i \cdot \bar r}$$

$$\nabla \times \bar E = -j\omega\mu_0 \bar H = -j k_0 \eta_0 \bar H$$

$$= -j \bar k \times \bar E$$

$$k_0 = \omega\sqrt{\mu_0 \varepsilon_0}$$

$$\eta_0 = \sqrt{\frac{\mu_0}{\varepsilon_0}}$$

$$\eta_0 \bar H^{i,r} = \frac{\bar k^{i,r} \times \bar E^{i,r}}{k_0}$$

$$\bar E_t = \bar{\bar Z}_s \cdot \bar n \times \bar H_t$$

$$\Rightarrow \quad \bar E^i + \bar E^r = \bar{\bar Z}_s \cdot \bar n \times \left(\frac{\bar k^i \times \bar E^i}{k_0 \eta_0} + \frac{\bar k^r \times \bar E^r}{k_0 \eta_0} \right)$$

$$\Rightarrow \quad \eta_0 \bar E^i + \eta_0 \bar E^r = \bar{\bar Z}_s \cdot \bar n \times \left(-\bar n \times \bar E^i + \bar n \times \bar E^r \right)$$

$$\eta_0 \bar{\bar I}_t \cdot \bar E^i + \eta_0 \bar{\bar I}_t \cdot \bar E^r = \bar{\bar Z}_s \cdot \left(\bar E^i - \bar E^r \right)$$

$$\left(\bar{\bar Z}_s + \eta_0 \bar{\bar I}_t \right) \cdot \bar E^r = \left(\bar{\bar Z}_s - \eta_0 \bar{\bar I}_t \right) \cdot \bar E^i$$

$$\bar E^r = \left(\bar{\bar Z}_s + \eta_0 \bar{\bar I}_t \right)^{-1} \cdot \left(\bar{\bar Z}_s - \eta_0 \bar{\bar I}_t \right) \cdot \bar E^i$$

$$\bar{E}^r = \underbrace{\left(\bar{\bar{Z}}_s + \eta_0 \bar{\bar{I}}_t\right)^{-1} \cdot \left(\bar{\bar{Z}}_s - \eta_0 \bar{\bar{I}}_t\right)}_{\bar{\bar{R}}} \cdot \bar{E}^i$$

$$\bar{\bar{Z}}_s = Z_I \bar{\bar{I}}_t$$

$$\bar{\bar{R}} = (\bar{\bar{Z}}_s + \eta_0 \bar{\bar{I}}_t)^{-1} \cdot (\bar{\bar{Z}}_s - \eta_0 \bar{\bar{I}}_t) = \frac{Z_I - \eta_0}{Z_I + \eta_0} \bar{\bar{I}}_t$$

PEMC: $\bar{\bar{Z}}_s = Z_J \bar{\bar{J}} = \frac{1}{M} \bar{\bar{J}} \times \bar{n} \times \bar{\bar{I}}_t$

$$\det \bar{\bar{A}} = \lambda_1 \lambda_2 \lambda_3$$
$$\operatorname{spm} \bar{\bar{A}} = \lambda_1 \lambda_2 + \lambda_2 \lambda_3 + \lambda_3 \lambda_1$$
$$\operatorname{tr} \bar{\bar{A}} = \lambda_1 + \lambda_2 + \lambda_3$$

2D $\quad \det \bar{\bar{J}} = 0 \quad \operatorname{spm} \bar{\bar{J}} = \lambda_1 \lambda_2 \quad \operatorname{tr} \bar{\bar{J}} = \lambda_1 + \lambda_2 = 0$

$$\operatorname{spm} \bar{\bar{J}} = \operatorname{tr}\left(\frac{1}{2} \underbrace{\bar{\bar{J}} \,{}^{\times}_{\times}\, \bar{\bar{J}}}_{\bar{n} \times \bar{\bar{I}} \,{}^{\times}_{\times}\, \bar{n} \times \bar{\bar{I}} = 2\bar{n}\bar{n}}\right) = \operatorname{tr} \bar{n}\bar{n} = \bar{n} \cdot \bar{n} = 1 = \lambda_1 \lambda_2 = -\lambda_1^2$$

$$\lambda_1 = +j$$
$$\lambda_2 = -j$$

Eigenvectors of $\bar{\bar{J}}$?

$$\bar{\bar{J}} \cdot (\bar{u} + \alpha \bar{v}) = +j(\bar{u} + \alpha \bar{v})$$
$$= \bar{v} - \alpha \bar{u}$$

$$\bar{e}_1 = \bar{u} - j\bar{v} \quad (\lambda_1 = j)$$
$$\bar{e}_2 = \bar{u} + j\bar{v} \quad (\lambda_2 = -j)$$

REFLECTION COEFFICIENT

$$\bar{\bar{Z}}_s = Z_J \bar{\bar{J}}.$$

$$1/m$$

$$\bar{\bar{R}} = \left(\bar{\bar{Z}}_s + \eta_0 \bar{\bar{I}}_t\right)^{-1} \cdot \left(\bar{\bar{Z}}_s - \eta_0 \bar{\bar{I}}_t\right)$$

$$= \left(Z_J \bar{\bar{J}} + \eta_0 \bar{\bar{I}}_t\right)^{-1} \cdot \left(Z_J \bar{\bar{J}} - \eta_0 \bar{\bar{I}}_t\right)$$

$$\bar{\bar{A}} = \alpha \bar{\bar{I}}_t + \beta \bar{\bar{J}} \quad \Rightarrow \quad \bar{\bar{A}}^{-1} = \frac{\alpha \bar{\bar{I}}_t - \beta \bar{\bar{J}}}{\alpha^2 + \beta^2}$$

(2.188)

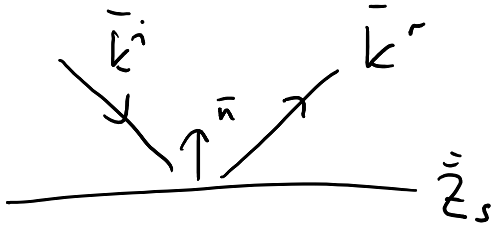
$$\bar{\bar{R}} = \frac{1}{Z_J^2 + \eta_0^2}\left(\eta_0 \bar{\bar{I}}_t - Z_J \bar{\bar{J}}\right) \cdot \left(Z_J \bar{\bar{J}} - \eta_0 \bar{\bar{I}}_t\right)$$

$$= \frac{1}{Z_J + \eta_0^2}\left(Z_J \eta_0 \bar{\bar{J}} - \eta_0^2 \bar{\bar{I}}_t + Z_J^2 \bar{\bar{I}}_t + \eta_0 Z_s \bar{\bar{J}}\right)$$

$$= \frac{1}{\eta_0^2 + Z_J^2}\left(\left(Z_J^2 - \eta_0^2\right) \bar{\bar{I}}_t + 2\eta_0 Z_J \bar{\bar{J}}\right)$$

OBLIQUE INCIDENCE

$$\bar{\bar{J}}_t = \frac{1}{k_0 k_n}\,\bar{n} \times \left(\bar{k}_t \bar{k}_t + k_n^2 \bar{\bar{I}}_t\right)$$



$$\bar{k}^i \cdot \bar{k}^i = \bar{k}^r \cdot \bar{k}^r = k_0^2$$

$$\bar{k}^i = \bar{k}_t - \bar{n}\, k_n$$

$$\bar{k}^r = \bar{k}_t + \bar{n}\, k_n$$

$$\Downarrow$$

NORMAL INCIDENCE

$\bar{k}_t = 0\,, \quad k_n = k_0$

$$\bar{\bar{J}}_t = \frac{1}{k_0^2}\,\bar{n} \times \left(\bar{0}\bar{0} + k_0^2 \bar{\bar{I}}_t\right)$$

$$= \bar{n} \times \bar{\bar{I}}_t = \bar{\bar{J}}$$

ANOTHER FORM

$$\left(\bar{\bar{I}}_t = \frac{\bar{k}_t \bar{k}_t + \bar{n}\times\bar{k}_t\;\bar{n}\times\bar{k}_t}{k_t^2} \right)$$

$$\bar{\bar{J}}_t = \frac{1}{k_0 k_n}\,\bar{n} \times \left(\bar{k}_t \bar{k}_t + \frac{k_n^2}{k_t^2}\,\bar{k}_t \bar{k}_t + \frac{k_n^2}{k_t^2}\,\bar{n}\times\bar{k}_t\;\bar{n}\times\bar{k}_t\right)$$

$$= \frac{1}{k_0 k_n}\left[(\bar{n}\times\bar{k}_t)\bar{k}_t\,\frac{k_t^2 + k_n^2}{k_t^2} - \frac{k_n^2}{k_t^2}\,\bar{k}_t(\bar{n}\times\bar{k}_t) \right]$$

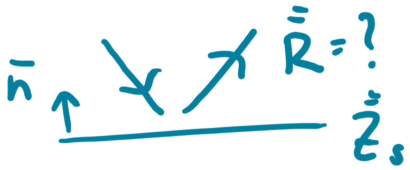
$$= \frac{k_0}{k_n k_t^2}\,(\bar{n}\times\bar{k}_t)\bar{k}_t - \frac{k_n}{k_0 k_t^2}\,\bar{k}_t(\bar{n}\times\bar{k}_t)$$

$$= \frac{1}{k_t^2}\left(\frac{k_0}{k_n}\,(\bar{n}\times\bar{k}_t)\,\bar{k}_t - \frac{k_n}{k_0}\,\bar{k}_t(\bar{n}\times\bar{k}_t) \right)$$

$$\bar{E}_t^i = \bar{\bar{J}}_t \cdot \eta_0 \bar{H}_t^i \qquad \eta_0 \bar{H}_t^i = -\bar{\bar{J}}_t \cdot \bar{E}_t^i$$

$$\left(\bar{\bar{J}}_t \cdot \bar{\bar{J}}_t = -\bar{\bar{I}}_t\right)$$

$$\bar{E}_t^r = -\bar{\bar{J}}_t \cdot \eta_0 \bar{H}_t^r \qquad \eta_0 \bar{H}_t^r = \bar{\bar{J}}_t \cdot \bar{E}_t^r$$



$$\bar{E}_t = \bar{\bar{Z}}_s \cdot (\bar{n} \times \bar{H}_t)$$

$$\bar{E}_t^i + \bar{E}_t^r = \bar{\bar{Z}}_s \cdot \bar{n} \times \left(-\frac{\bar{\bar{J}}_t \cdot \bar{E}_t^i}{\eta_0} + \frac{\bar{\bar{J}}_t \cdot \bar{E}_t^r}{\eta_0} \right)$$

$$\left(-\bar{\bar{Z}}_s \cdot \bar{n} \times \bar{\bar{J}}_t + \eta_0 \bar{\bar{I}}_t\right) \cdot \bar{E}_t^r = \left(-\bar{\bar{Z}}_s \cdot \bar{n} \times \bar{\bar{J}}_t - \eta_0 \bar{\bar{I}}_t\right) \cdot \bar{E}_t^i$$

$$\bar{E}_t^r = \bar{\bar{R}}_t \cdot \bar{E}_t^i$$

$$\bar{\bar{R}}_t = \left(\bar{\bar{Z}}_s \cdot \bar{n} \times \bar{\bar{J}}_t - \eta_0 \bar{\bar{I}}_t\right)^{-1} \cdot \left(\bar{\bar{Z}}_s \cdot \bar{n} \times \bar{\bar{J}}_t + \eta_0 \bar{\bar{I}}_t\right)$$

$$\bar{\bar{J}}_t \cdot \bar{\bar{J}}_t = ?$$

$$\frac{1}{k_t^{2\cdot 2}} \left(\frac{k_0}{k_n} \bar{n} \times \bar{k}_t \bar{k}_t - \frac{k_n}{k_0} \bar{k}_t \bar{n} \times \bar{k}_t \right) \cdot \left(\frac{k_0}{k_n} \bar{n} \times \bar{k}_t \bar{k}_t - \frac{k_n}{k_0} \bar{k}_t \bar{n} \times \bar{k}_t \right)$$

$$= \frac{1}{k_t^4} \left[-k_t^2 \cancel{\frac{k_0}{k_n} \frac{k_n}{k_0}} \bar{n} \times \bar{k}_t \bar{n} \times \bar{k}_t - k_t^2 \cancel{\frac{k_n}{k_0} \frac{k_0}{k_n}} \bar{k}_t \bar{k}_t \right]$$

$$= \frac{-1}{k_t^2}\left(\bar{k}_t\bar{k}_t + \bar{n}\times\bar{k}_t\,\bar{n}\times\bar{k}_t\right) = -\bar{\bar{I}}_t$$