

**8.34** Show that for nonmagnetic media, the reflection coefficient  $\Gamma_{\parallel}$  can be written in the following form:

$$\Gamma_{\parallel} = \frac{\tan(\theta_t - \theta_i)}{\tan(\theta_t + \theta_i)}.$$

**Solution:** From Eq. (8.66a),  $\Gamma_{\parallel}$  is given by

$$\Gamma_{\parallel} = \frac{\eta_2 \cos \theta_t - \eta_1 \cos \theta_i}{\eta_2 \cos \theta_t + \eta_1 \cos \theta_i} = \frac{(\eta_2/\eta_1) \cos \theta_t - \cos \theta_i}{(\eta_2/\eta_1) \cos \theta_t + \cos \theta_i}.$$

For nonmagnetic media,  $\mu_1 = \mu_2 = \mu_0$  and

$$\frac{\eta_2}{\eta_1} = \sqrt{\frac{\epsilon_1}{\epsilon_2}} = \frac{n_1}{n_2}.$$

Snell's law of refraction is

$$\frac{\sin \theta_t}{\sin \theta_i} = \frac{n_1}{n_2}.$$

Hence,

$$\Gamma_{\parallel} = \frac{\frac{\sin \theta_t}{\sin \theta_i} \cos \theta_t - \cos \theta_i}{\frac{\sin \theta_t}{\sin \theta_i} \cos \theta_t + \cos \theta_i} = \frac{\sin \theta_t \cos \theta_t - \sin \theta_i \cos \theta_i}{\sin \theta_t \cos \theta_t + \sin \theta_i \cos \theta_i}.$$

To show that the expression for  $\Gamma_{\parallel}$  is the same as

$$\Gamma_{\parallel} = \frac{\tan(\theta_t - \theta_i)}{\tan(\theta_t + \theta_i)},$$

we shall proceed with the latter and show that it is equal to the former.

$$\frac{\tan(\theta_t - \theta_i)}{\tan(\theta_t + \theta_i)} = \frac{\sin(\theta_t - \theta_i) \cos(\theta_t + \theta_i)}{\cos(\theta_t - \theta_i) \sin(\theta_t + \theta_i)}.$$

Using the identities (from Appendix C):

$$2 \sin x \cos y = \sin(x + y) + \sin(x - y),$$

and if we let  $x = \theta_t - \theta_i$  and  $y = \theta_t + \theta_i$  in the numerator, while letting  $x = \theta_t + \theta_i$  and  $y = \theta_t - \theta_i$  in the denominator, then

$$\frac{\tan(\theta_t - \theta_i)}{\tan(\theta_t + \theta_i)} = \frac{\sin(2\theta_t) + \sin(-2\theta_i)}{\sin(2\theta_t) + \sin(2\theta_i)}.$$

But  $\sin 2\theta = 2 \sin \theta \cos \theta$ , and  $\sin(-\theta) = -\sin \theta$ , hence,

$$\frac{\tan(\theta_t - \theta_i)}{\tan(\theta_t + \theta_i)} = \frac{\sin \theta_t \cos \theta_t - \sin \theta_i \cos \theta_i}{\sin \theta_t \cos \theta_t + \sin \theta_i \cos \theta_i},$$

which is the intended result.

---