Reflectionless Evanescent Wave Amplification by Two Dielectric Slabs

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Optics Letters, **31**, 2741 (2006).

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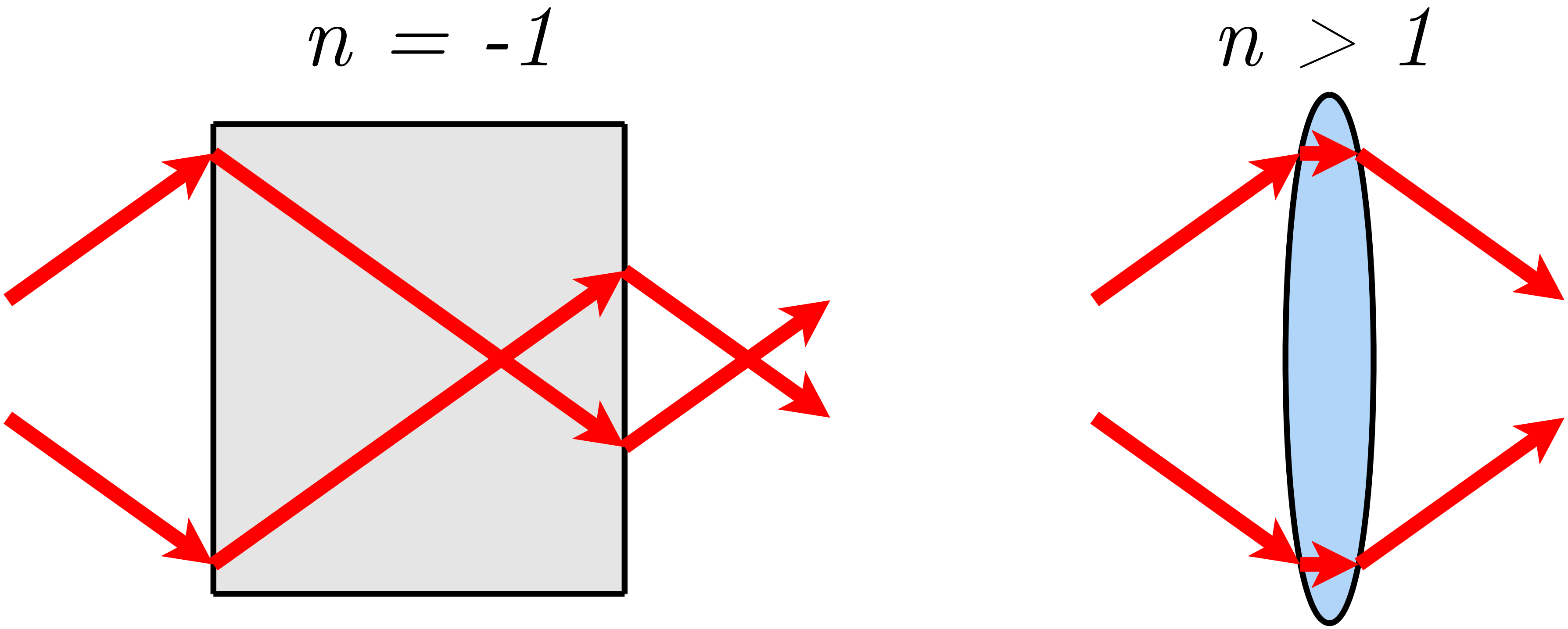
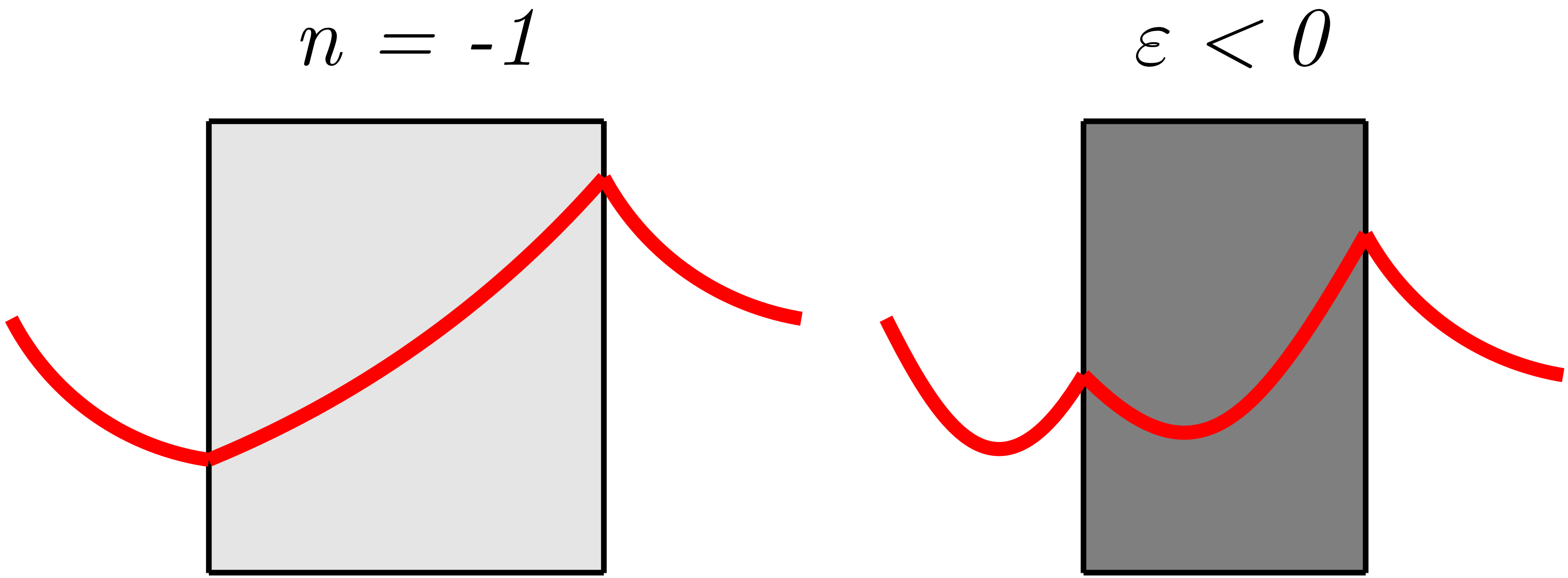
Outline

- Negative Index of Refraction
- Physics of Evanescent Wave Amplification
- Dielectric Slabs
- Simple example

Veselago: Negative Refraction

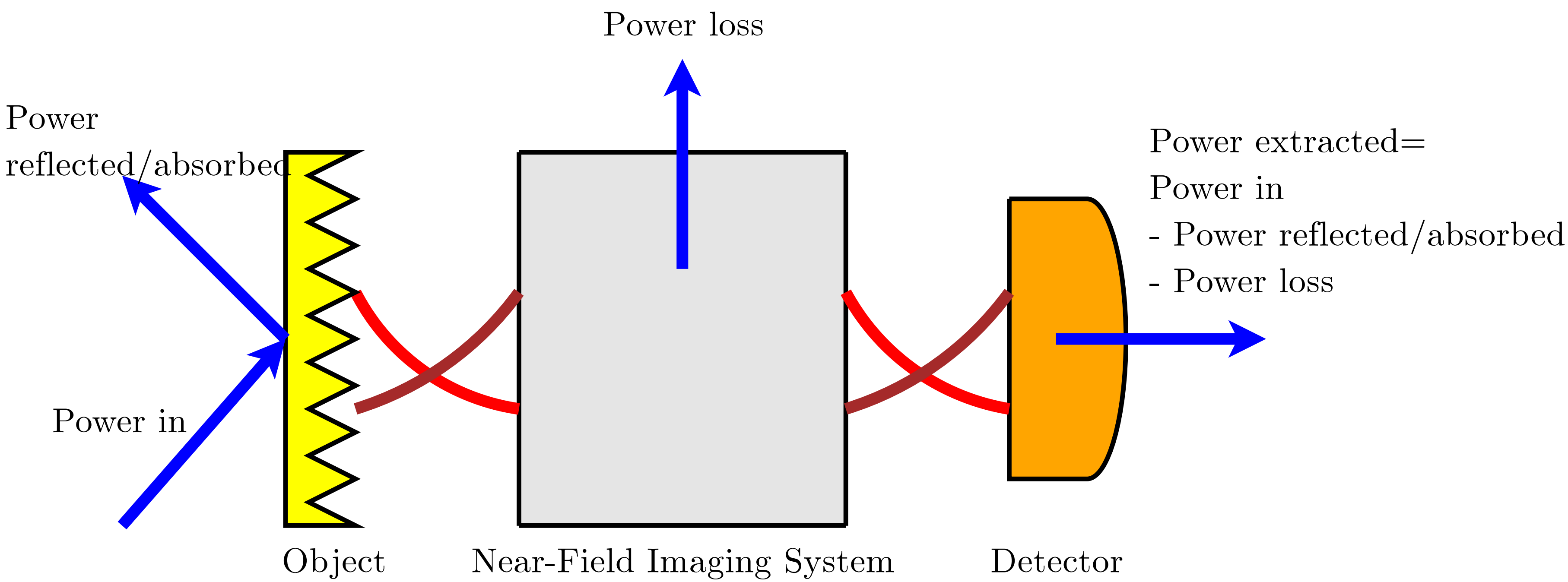


Sir Pendry: Evanescent Wave Amplification

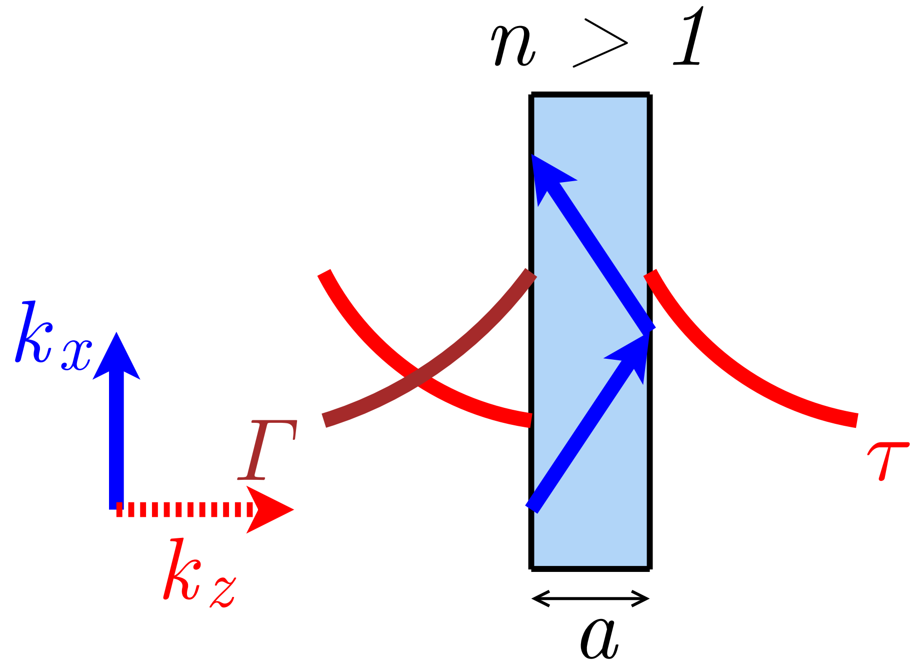


$$T \to \exp(-ik_z d), \quad R \to 0 \tag{1}$$

Importance of Low Loss



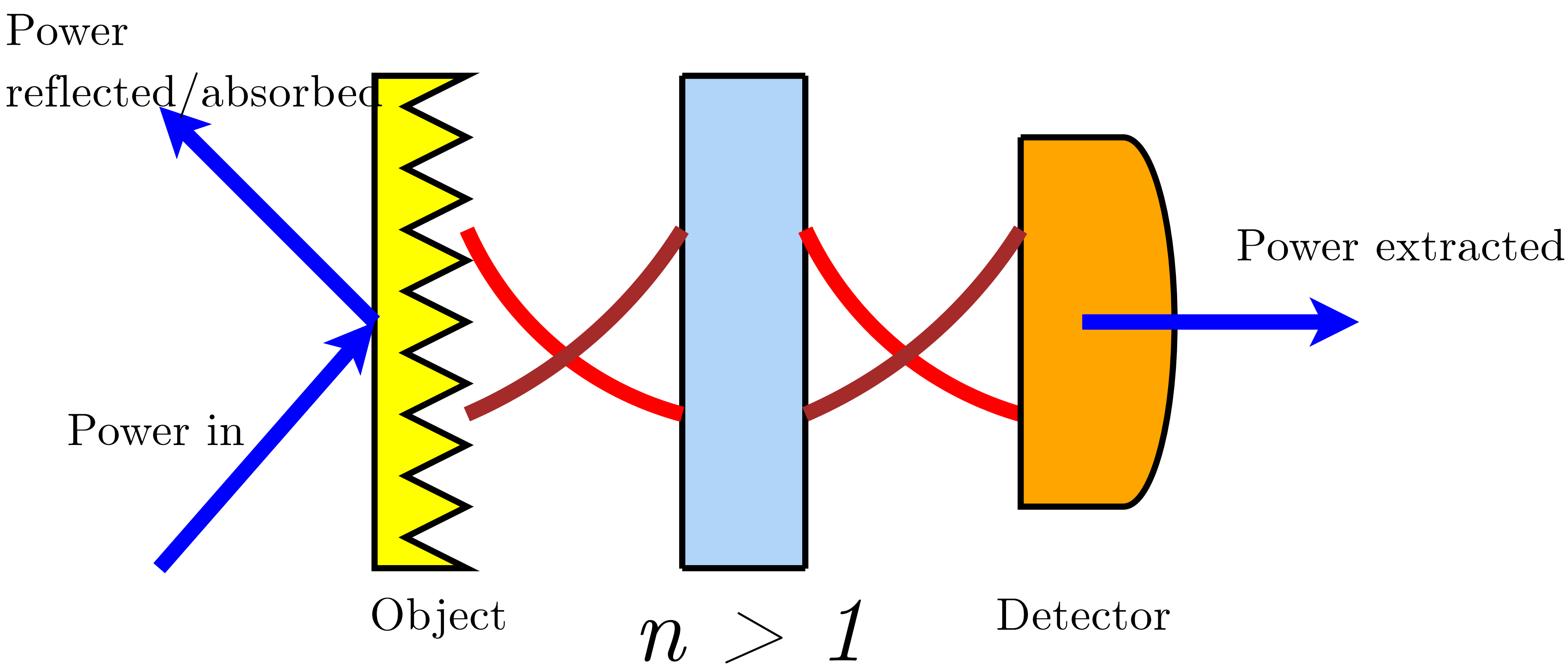
One Dielectric Slab



$$\tau = \frac{tt' \exp(ik_z' a)}{1 - r'^2 \exp(2ik_z' a)}, \quad \Gamma = r + \frac{tt' r' \exp(2ik_z' a)}{1 - r'^2 \exp(2ik_z' a)} \tag{2}$$

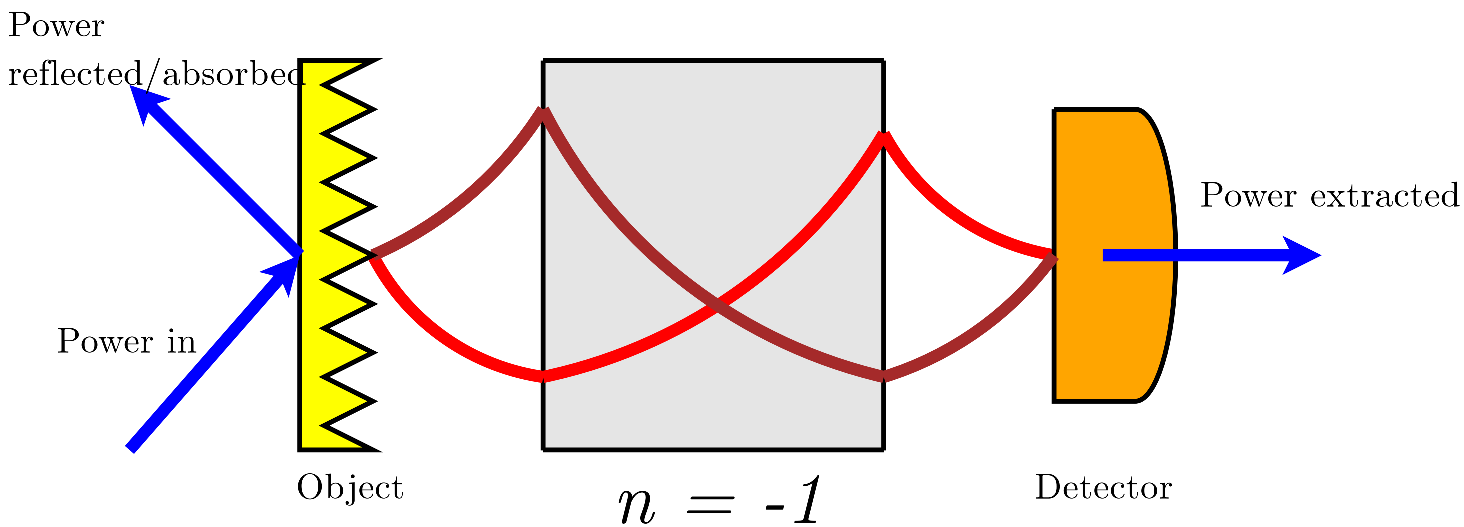
$$\tau \longrightarrow \infty \text{ and } \Gamma \longrightarrow \infty \text{ if } r'^2 \exp(2ik_z' a) \longrightarrow 1 \tag{3}$$

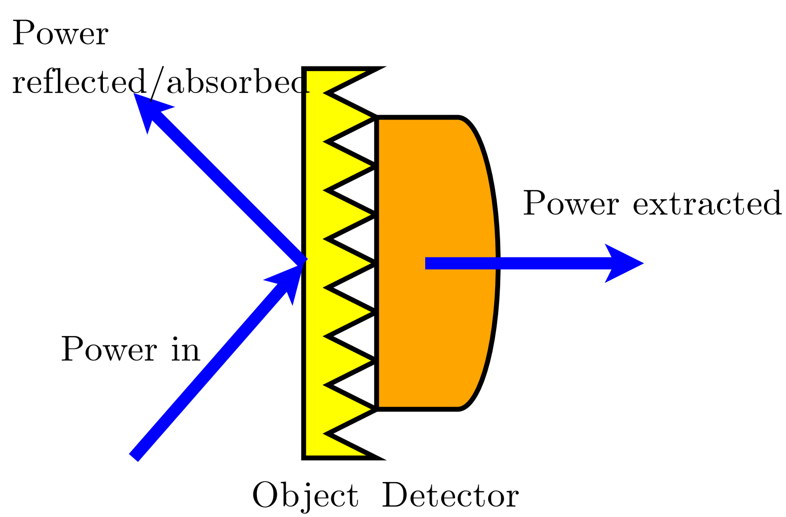
The Problem of Multiple Evanescent-Wave Reflections



$$\tau \longrightarrow \infty \text{ and } \Gamma \longrightarrow \infty \text{ if } r'^2 \exp(2ik'_z a) \longrightarrow 1 \quad (4)$$

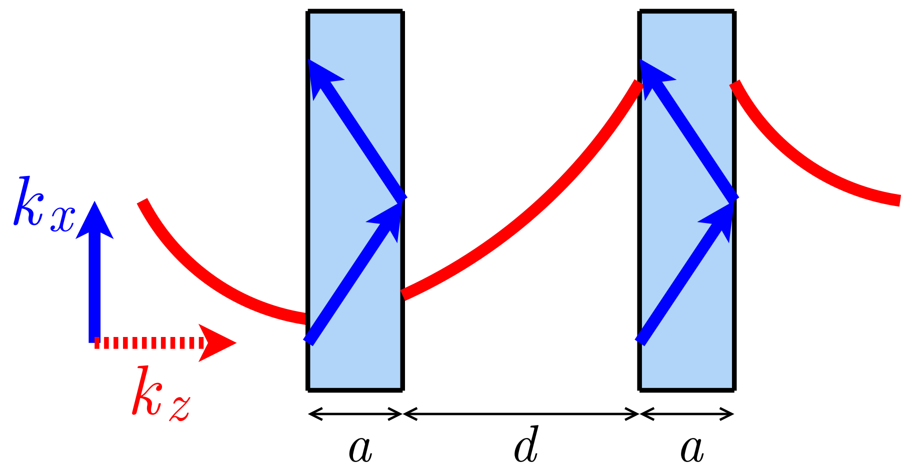
Ideal Negative Index of Refraction Behaviour





$$T = 1, R = 0. \tag{5}$$

Two Dielectric Slabs



$$R = \Gamma + \frac{\tau^2 \Gamma \exp(2ik_z d)}{1 - \Gamma^2 \exp(2ik_z d)} = 0, \quad T = \frac{\tau^2 \exp(ik_z d)}{1 - \Gamma^2 \exp(2ik_z d)} = -\exp(-ik_z d) \tag{6}$$

for some k_x.

Correct Derivation

- Let

$$R = \Gamma + \frac{\tau^2 \Gamma \exp(2ik_z d)}{1 - \Gamma^2 \exp(2ik_z d)} = 0. \tag{7}$$

- Neglect the case where $\Gamma = 0$,

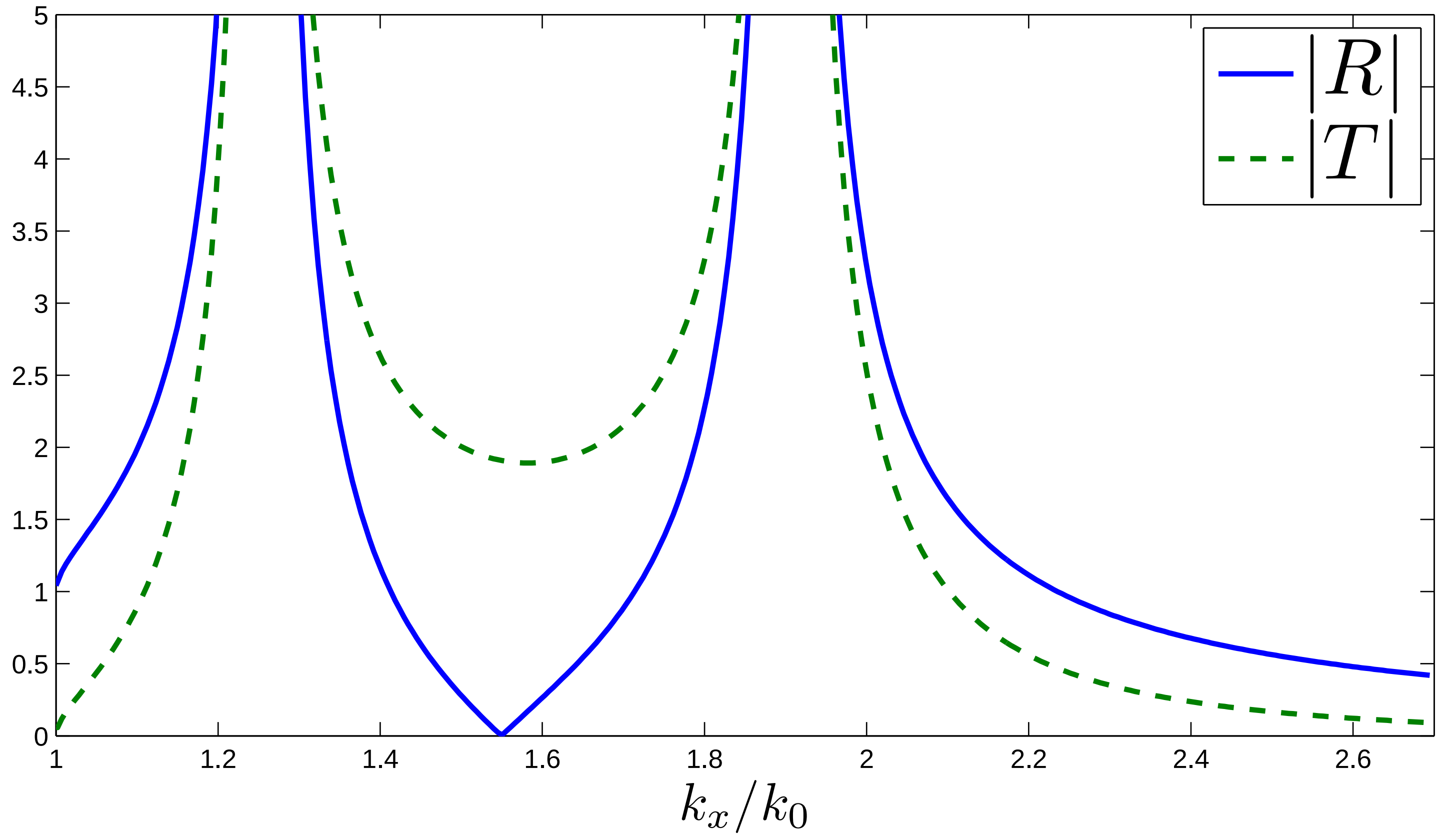
$$\tau^2 = \Gamma^2 - \exp(-2ik_z d). \tag{8}$$

- Given Eq. (8), the transmission coefficient T is always

$$T = \frac{\tau^2 \exp(ik_z d)}{1 - \Gamma^2 \exp(2ik_z d)} = -\exp(-ik_z d). \tag{9}$$

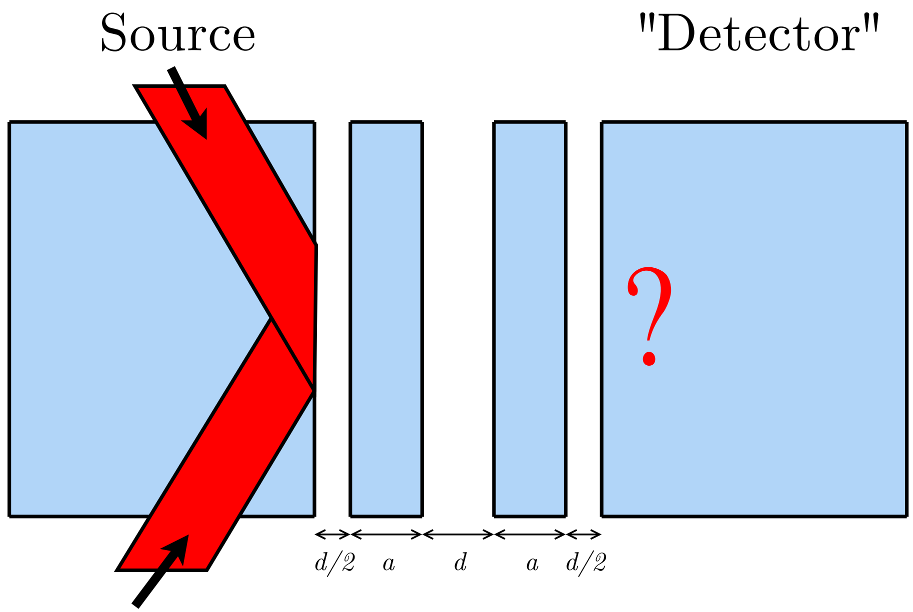
Does R go to zero at all?

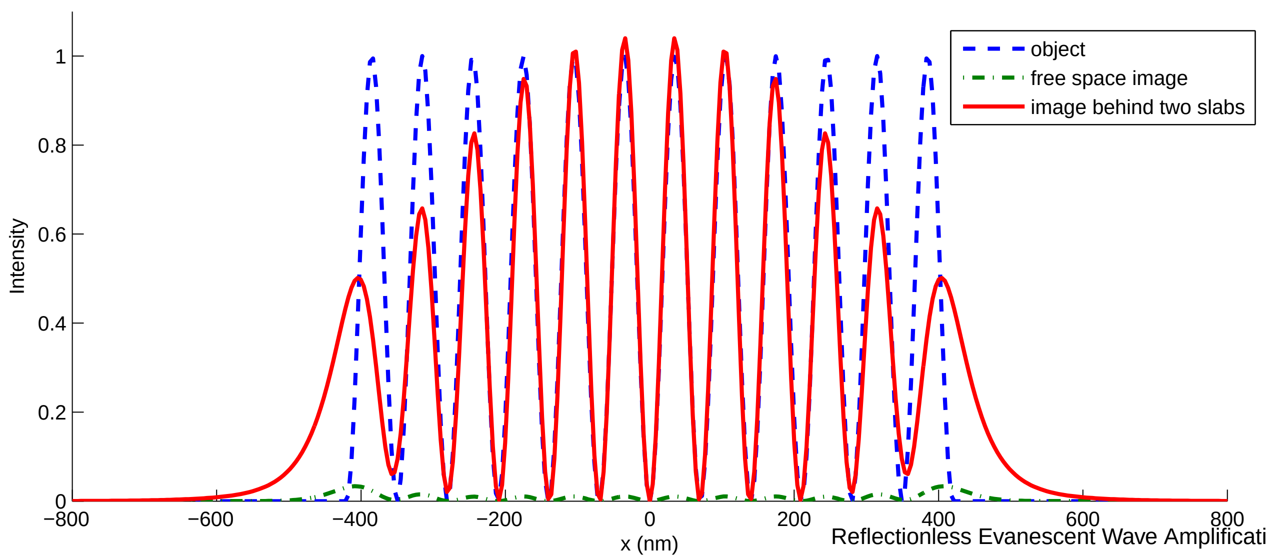
- Let $\lambda = 230$ nm, $n = 2.7$ (diamond), $a = 20$ nm, $d = 20$ nm, TE polarization,



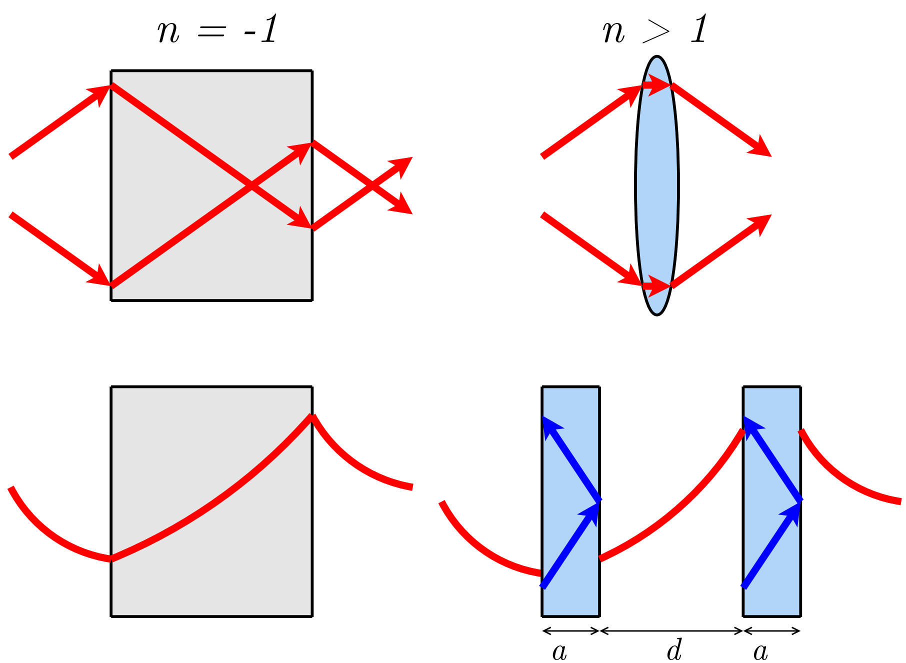
Simple Example Including a Source and a Detector

$\lambda = 230$ nm, $n = 2.7$, $a = 20$ nm, $d = 20$ nm, TE polarization,





Conclusion



- Low loss
- many modes
- High refractive index material available (transparent down to $\lambda = 230$ nm, $n = 2.7$ for diamond)
- non-contact imaging, suitable for lithography and bio-imaging