# Fabry-Perot Cavities

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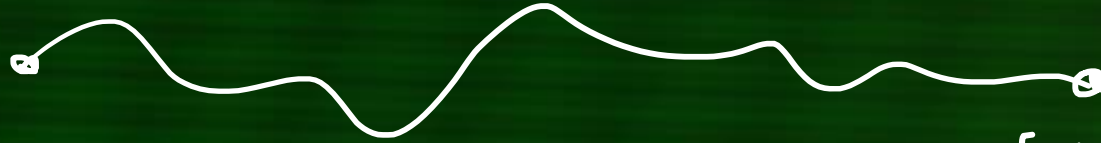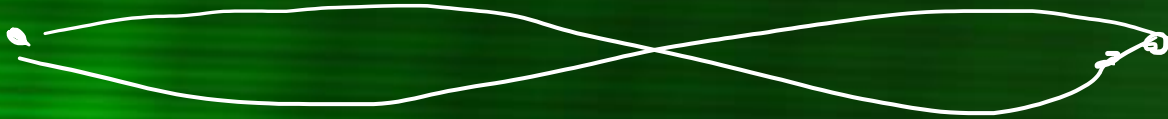
# Business

- I9 Form

# Measuring Linewidth / Lineshape

- What is linewidth
- Methods
  - Interferometry
  - Fabry-Perot Etalon

# Resonance on a Guitar String: Frequency



$$A_n \sin(k_n x) \cos(w_n t + \phi_n)$$
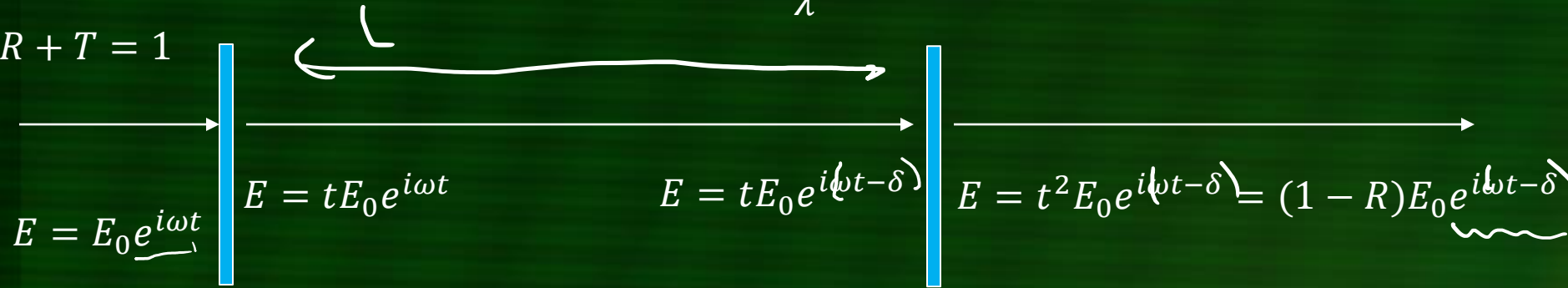
# Resonance on a Guitar String: Spatial Mode

# Optical Cavity in 1D

$t = \sqrt{T}$

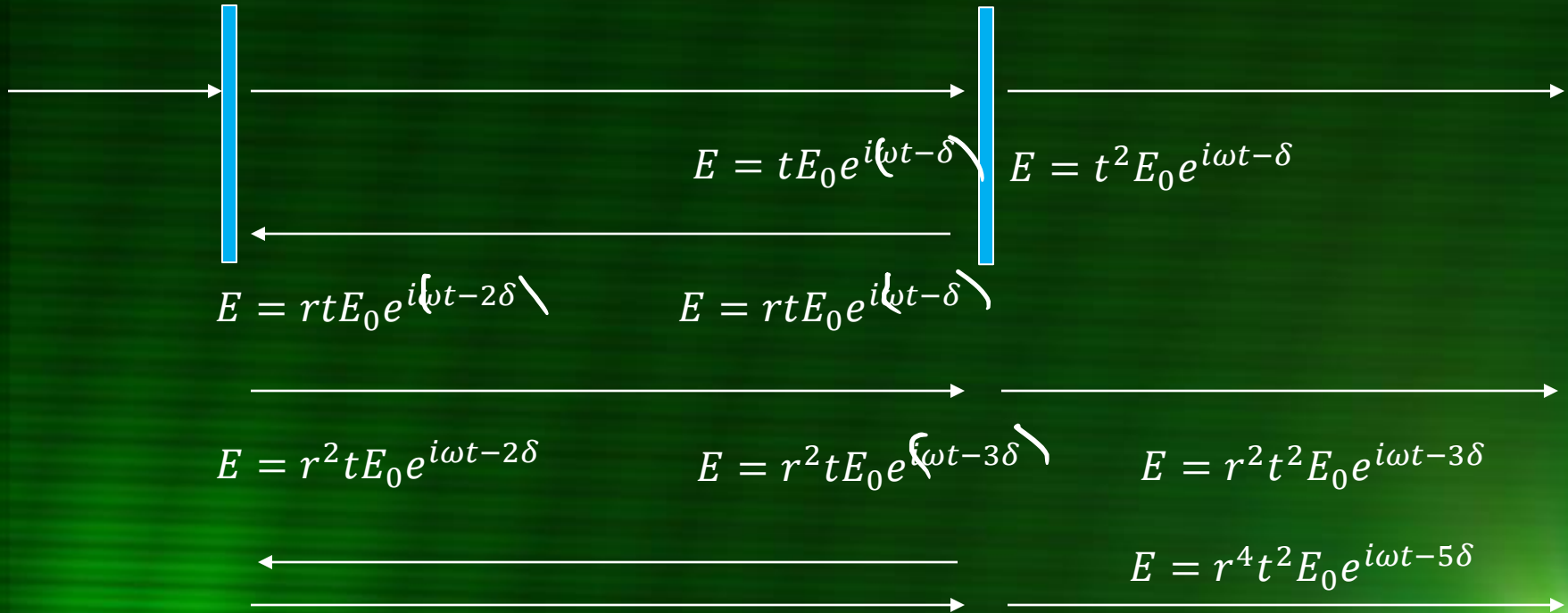$r = \sqrt{R}$

$R + T = 1$

$\delta = \dfrac{2\pi L}{\lambda}$

$E = tE_0 e^{i\omega t}$

$E = tE_0 e^{i(\omega t - \delta)}$

$E = t^2 E_0 e^{i(\omega t - \delta)} = (1 - R)E_0 e^{i(\omega t - \delta)}$

$E = E_0 e^{i\omega t}$

$I \propto |E|^2 = E^* E$

$I = (1 - R)^2 I_0$

# Optical Cavity in 1D

$$\delta = \frac{2\pi L}{\lambda}$$

$E = tE_0 e^{i(\omega t - \delta)}$

$E = t^2 E_0 e^{i\omega t - \delta}$

$E = rtE_0 e^{i(\omega t - 2\delta)}$

$E = rtE_0 e^{i(\omega t - \delta)}$

$E = r^2 tE_0 e^{i\omega t - 2\delta}$

$E = r^2 tE_0 e^{i(\omega t - 3\delta)}$

$E = r^2 t^2 E_0 e^{i\omega t - 3\delta}$

$E = r^4 t^2 E_0 e^{i\omega t - 5\delta}$

$$E = E_0 \sum_{n=0}^{\infty} t^2 \, r^{2n} \, e^{i(\omega t + (2n+1)\delta)}$$

$$= t^2 \, e^{i\omega t} \, e^{i\delta} E_0 \underbrace{\sum_{n=0}^{\infty} r^{2n} \, e^{i2n\delta}}_{S} \qquad \alpha = r^2 e^{2i\delta}$$

$$S = \sum_{n=0}^{\infty} \alpha^n = \alpha \sum_{n=1}^{\infty} \alpha^n$$

$$S = \sum_{n=0}^{\infty} \alpha^n = 1 + \sum_{n=1}^{\infty} \alpha^n$$

$$= 1 + \alpha \sum_{n=0}^{\infty} \alpha^n$$

$$= 1 + \alpha S$$

$$S(1-\alpha) = 1$$

$$S = \frac{1}{1-\alpha}$$

$$E = t^2 E_0 \, e^{i\omega t} \, e^{i\delta} \, \frac{1}{1 - r^2 e^{2i\delta}}$$

$$I = t^4 I_0 \, \frac{1}{1 - r^2 e^{2i\delta}} \, \frac{1}{1 - r^2 e^{-2i\delta}}$$

$$= t^4 I_0 \, \frac{1}{1 - r^2 e^{-2i\delta} - r^2 e^{2i\delta} + r^4}$$

$$= t^4 I_0 \, \frac{1}{1 - r^2}$$

$$e^{i\theta} = i\sin\theta + \cos\theta$$

$$e^{-i\theta} = i\sin(-\theta) + \cos(-\theta)$$

$$= -i\sin\theta + \cos\theta$$

$$e^{i\theta} + e^{-i\theta} = 2\cos\theta$$

$$I = t^4 I_0 \frac{1}{1 - 2r^2 \cos(2\delta) + r^4}$$

$$I = \frac{(1-R)^2}{1 - 2R\cos(2\delta) + R^2}$$
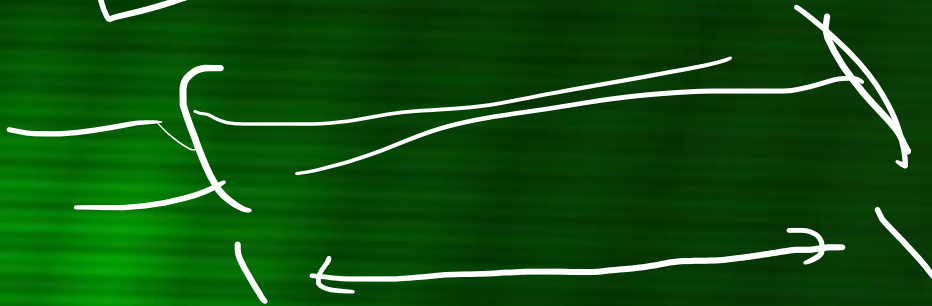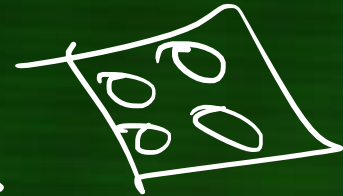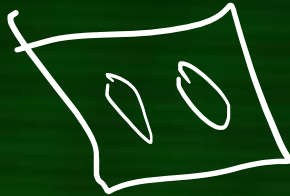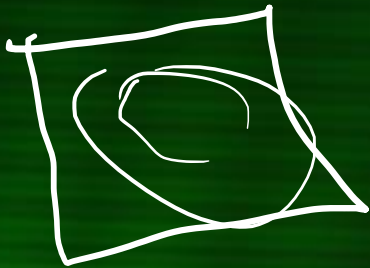
$$\cos\delta = 1$$

$$\frac{(1-R)^2}{1 - 2R + R^2} = 1$$

$$\frac{(1-R)^2}{(1-R)(1+R)}$$

$$\cos\delta = -1$$

$$\frac{(1-R)^2}{1 + 2R + R^2}$$

$$\delta = \frac{2\pi L}{\lambda}$$

# 3D Resonators

# Optical Isolators