SLC 641 – Óptica

Licenciatura em Ciências Exatas – São Carlos

Aula 6

Natureza ondulatória: Difração e interferência (Interferência)

07/10/2020

Natureza ondulatória da luz

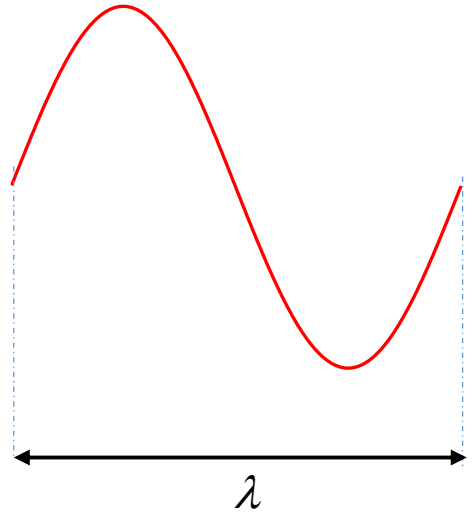
$$Comprimento\ de\ onda\ (\text{vácuo}) = \lambda = \frac{c}{frequência} = \frac{c}{\upsilon}$$

$$Comprimento\ de\ onda\ (\text{meio}) = \lambda_n = \frac{v}{\upsilon} = \frac{\lambda}{n}$$

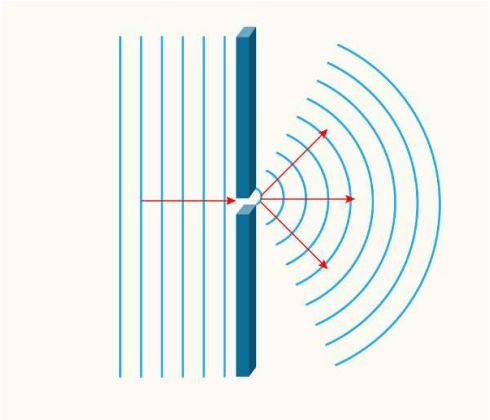
Frequência é constante, comprimento de onda no meio muda

$$c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$$

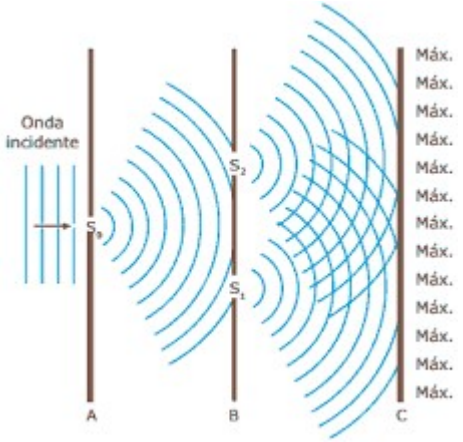
$$n = \frac{c}{velocidade} = \frac{c}{v}$$



Difração



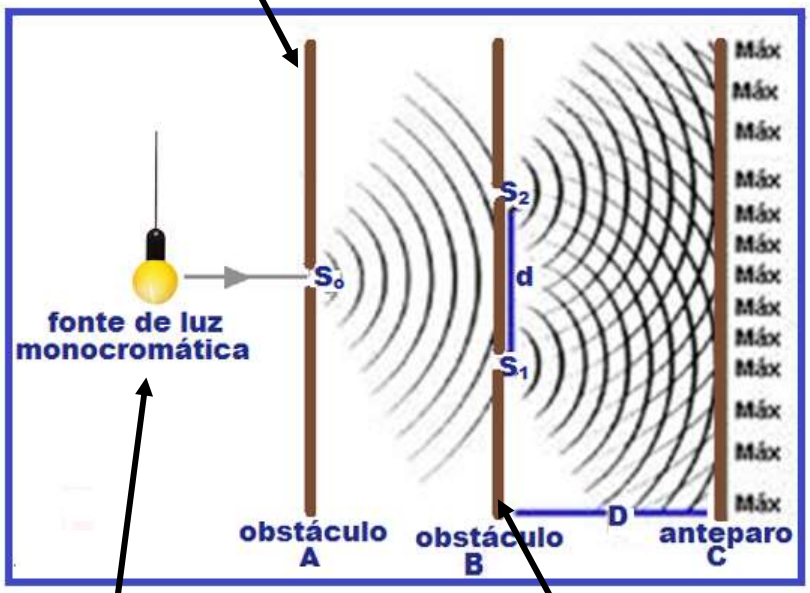
Interferência

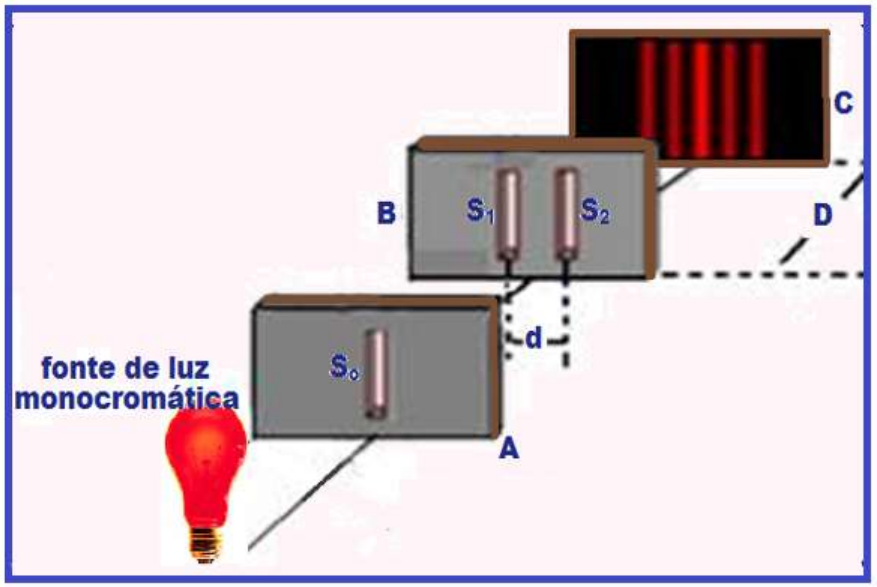


Interferência

Melhorar a coerência espacial

Experimento de Young



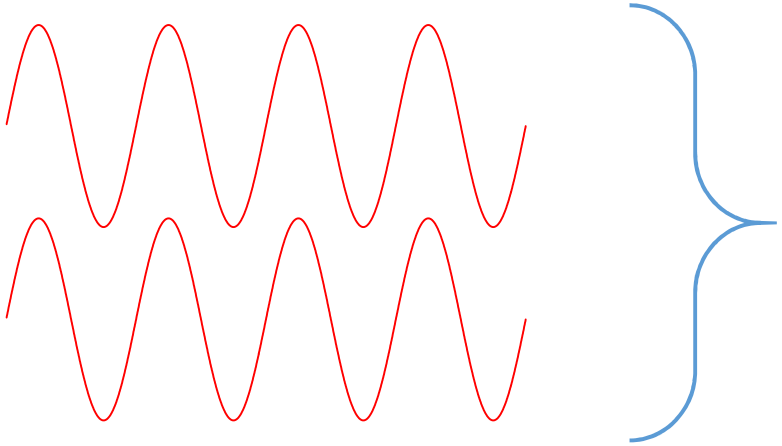


Definir um único λ (melhorar a coerência temporal)

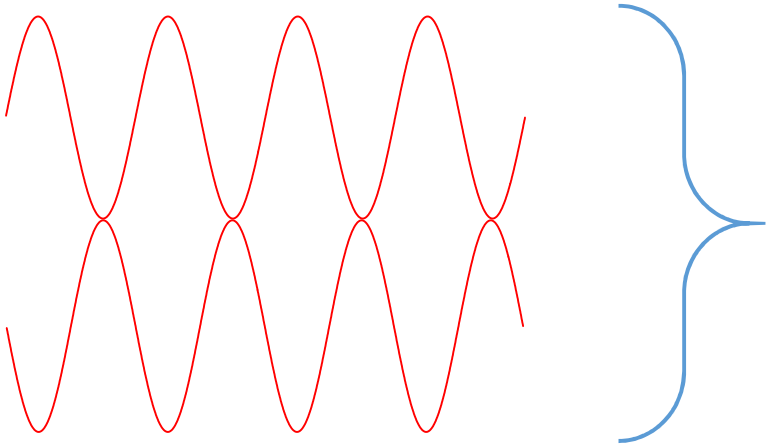
Interferência de duas fendas

Interferência

Princípio da superposição

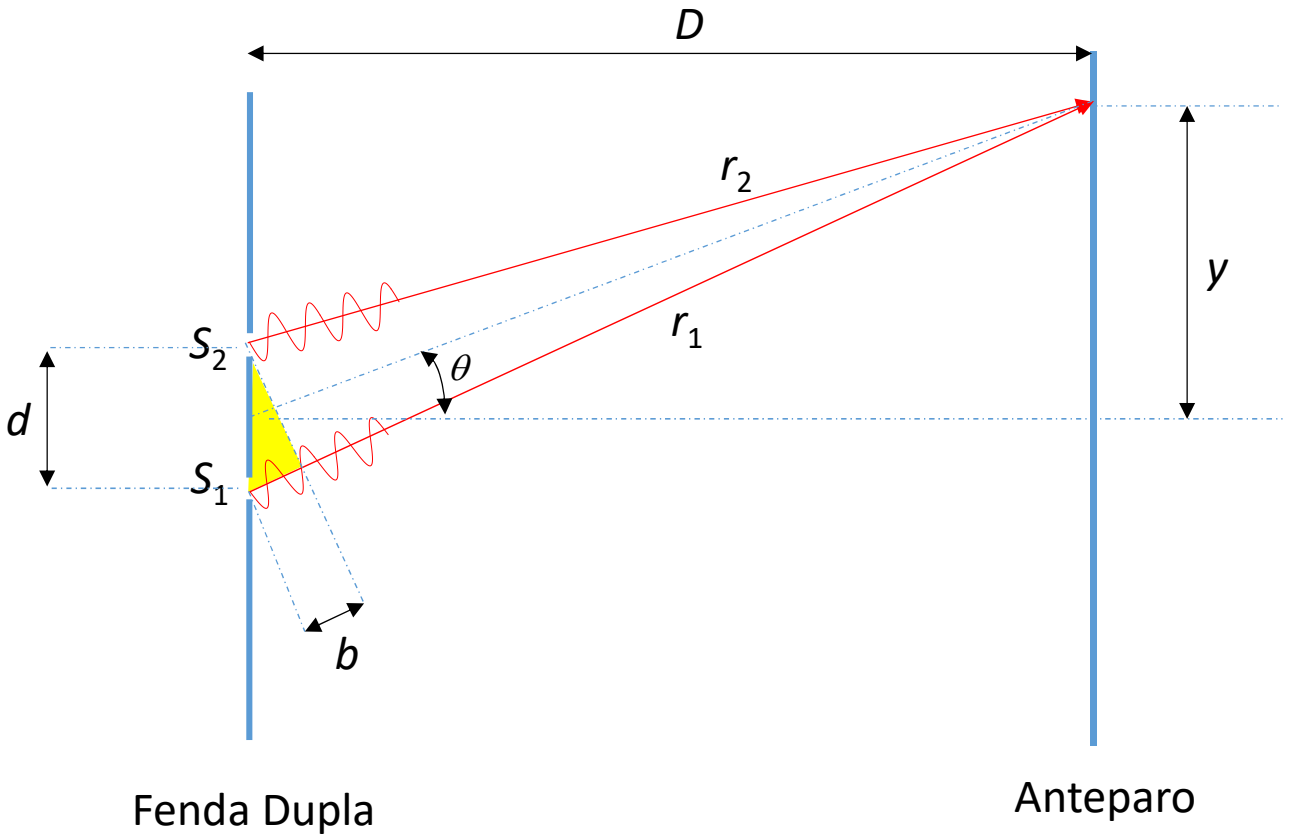


Ondas em fase
Interferência construtiva

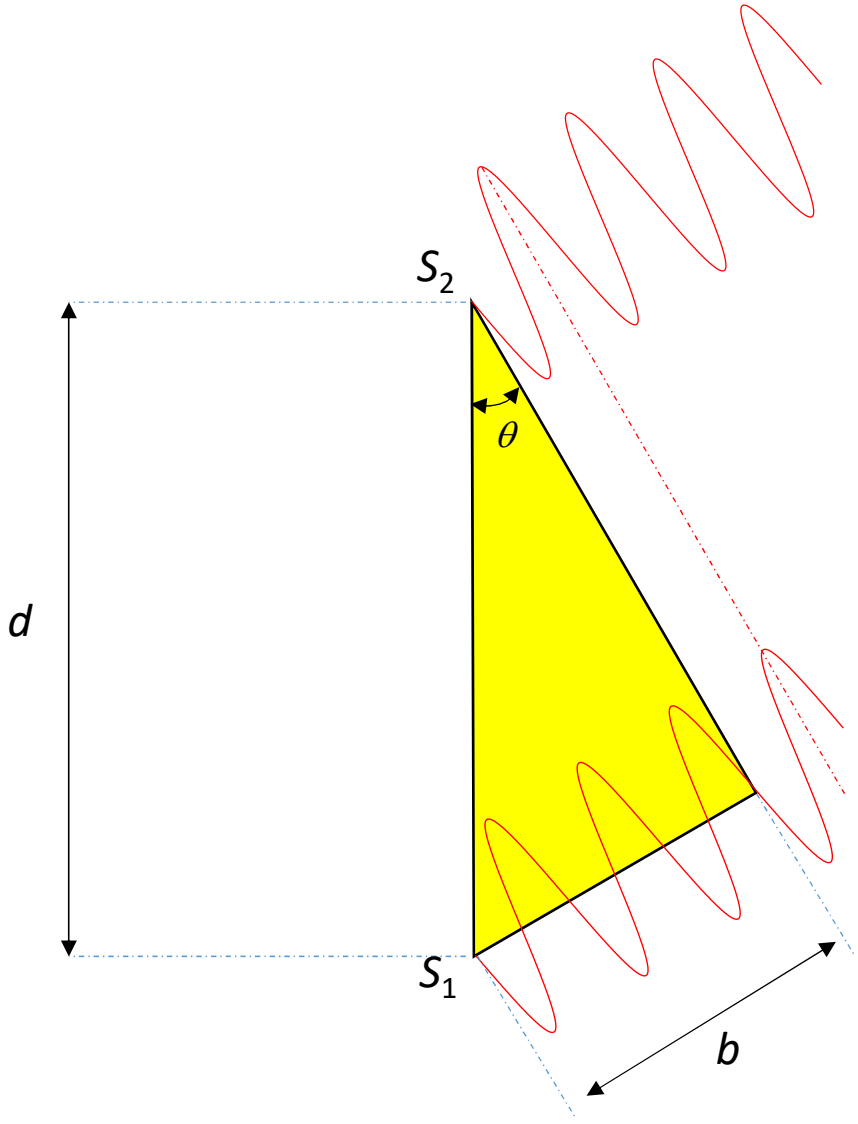


Ondas fora de fase ($180^{o}=\pi$)
Interferência destrutiva

Interferência de dupla fenda



Interferência de dupla fenda



$$sen\theta = \frac{b}{d}$$

$$b = m\lambda \qquad (m=0,1,2,3..)$$

$$d sen\theta = m\lambda$$ Máximos

Mínimos (π de atraso)

$$d sen\theta = \left(m + \frac{1}{2} \right) \lambda$$

Interferência de dupla fenda

Princípio da superposição

$$E = E_1[S_1] + E_2[S_2] \quad \begin{cases} E_1 = E_0 sen\ \omega t \\ E_2 = E_0 sen\ (\omega t + \phi) \end{cases}$$

$$\boxed{senA + senB = 2sen\frac{1}{2}(A+B)\cos\frac{1}{2}(A-B)}$$

$$E = E_0 sen\omega t + E_0 sen(\omega t + \phi) = 2E_0 sen\frac{1}{2}(\omega t + \omega t + \phi)\cos\frac{1}{2}(\omega t - \omega t - \phi)$$

$$E = 2E_0 \underbrace{sen\left(\omega t + \frac{\phi}{2}\right)}_{\text{Oscila rápido}} \underbrace{\cos\left(\frac{-\phi}{2}\right)}_{\text{Função par}}$$

$$\boxed{E = 2E_0\cos\left(\frac{\phi}{2}\right)} \quad \Rightarrow \quad \boxed{I = E^2 = 4I_0\cos^2\left(\frac{\phi}{2}\right)}$$

Interferência de dupla fenda

$$I = E^2 = 4I_0 \cos^2\left(\frac{\phi}{2}\right)$$ → Máximos quando: $\frac{\phi}{2} = m\pi$ (*m*=0,1,2,3..)

Portanto: $m = \frac{\phi}{2\pi}$ → $d\,sen\theta = m\lambda$

$$d\,sen\theta = \frac{\lambda\phi}{2\pi} \rightarrow \phi = \frac{2\pi d}{\lambda} sen\theta$$

Similarmente, os mínimos serão quando: $\frac{\phi}{2} = \left(m + \frac{1}{2}\right)\pi$ (*m*=0,1,2,3..)

$$\phi = \frac{2\pi d}{\lambda} sen\theta \rightarrow 2\left(m + \frac{1}{2}\right)\pi = \frac{2\pi d}{\lambda} sen\theta \rightarrow d\,sen\theta = \left(m + \frac{1}{2}\right)\lambda$$

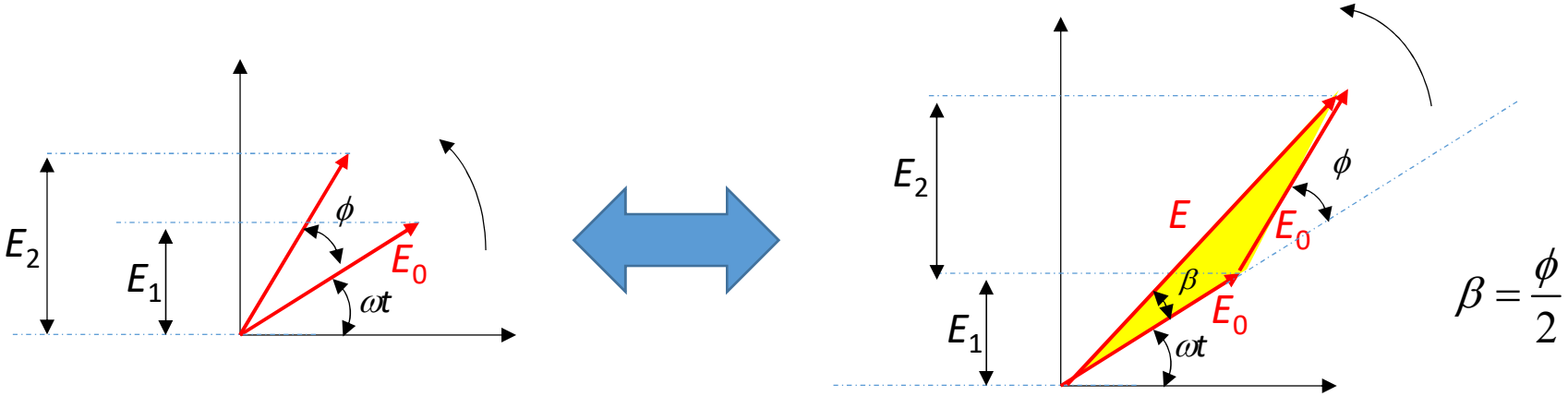
Interferência de dupla fenda

Fasor (método geométrico)

$$E = E_1[S_1] + E_2[S_2]$$

$$E_1 = E_0 sen\ \omega t$$

$$E_2 = E_0 sen\ (\omega t + \phi)$$



$$\cos\beta = \frac{E/2}{E_0} \Rightarrow E = 2(E_0 \cos\beta)$$

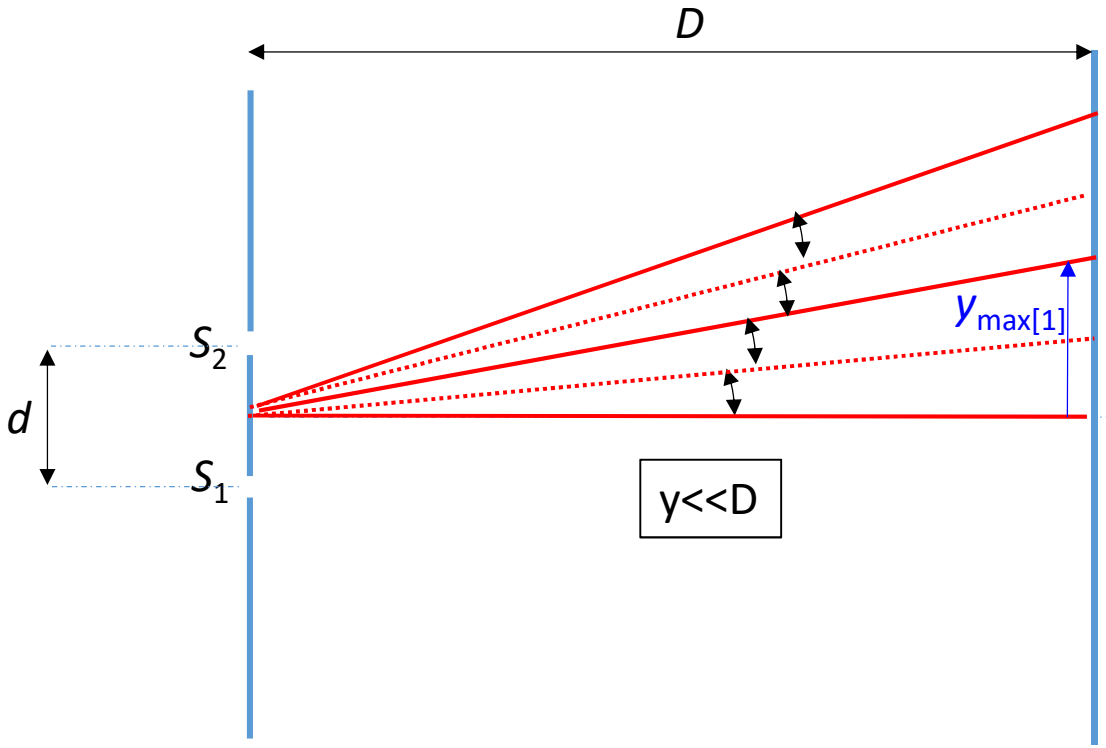
$$E = 2\left(E_0 \cos\frac{\phi}{2}\right) \Rightarrow \boxed{I = 4I_0 \cos^2\frac{\phi}{2}}$$

Interferência de dupla fenda

Máximos $dsen\theta = m\lambda$

Mínimos $dsen\theta = \left(m + \frac{1}{2}\right)\lambda$

(m=0,1,2,3..)



θ_{max}[m=2] $dsen\theta = 2\lambda \rightarrow sen\theta = 2\lambda/d$

θ_{min}[m=1] $dsen\theta = 3\lambda/2 \rightarrow sen\theta = 3\lambda/2d$

θ_{max}[m=1] $dsen\theta = \lambda \rightarrow sen\theta = \lambda/d$

θ_{min}[m=0] $dsen\theta = \lambda/2 \rightarrow sen\theta = \lambda/2d$

θ_{max}[m=0] $dsen\theta = 0 \rightarrow \theta = 0$

Para ângulos pequenos:

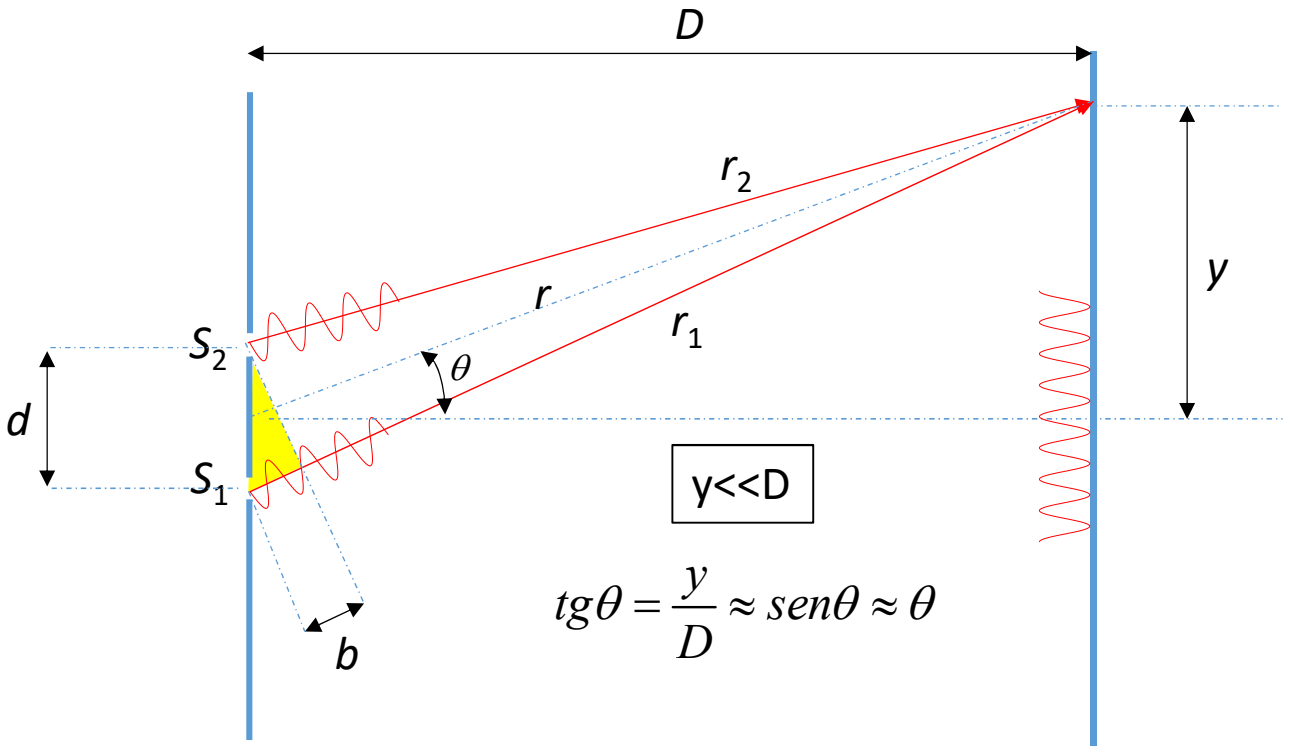
$$sen\theta \approx \theta = \frac{\lambda}{d} = \frac{y_{\max[1]}}{D}$$

$$y_{\max[1]} = \frac{D\lambda}{d}$$

Interferência de dupla fenda

$$I = 4I_0 \cos^2 \frac{\phi}{2}$$

$$\phi = \frac{2\pi d}{\lambda} sen\theta$$



$$tg\theta = \frac{y}{D} \approx sen\theta \approx \theta$$

$$I = 4I_0 \cos^2 \left(\frac{\pi d}{\lambda} \frac{y}{D} \right)$$

Interferência de dupla fenda

$$I = 4I_0 \cos^2\left(\frac{\pi d}{\lambda}\frac{y}{D}\right)$$