SLC 642 – Laboratório de Óptica

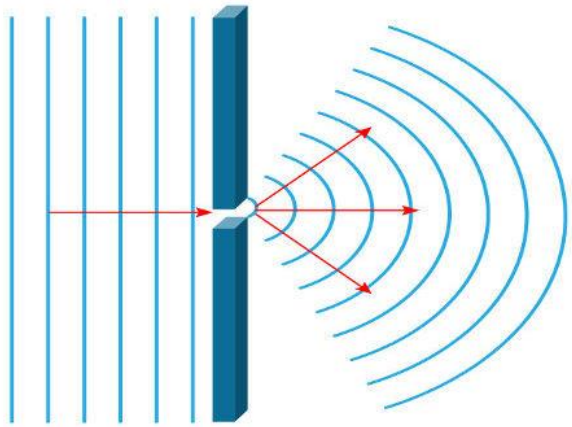
Licenciatura em Ciências Exatas – São Carlos

Prática 5:
Difração

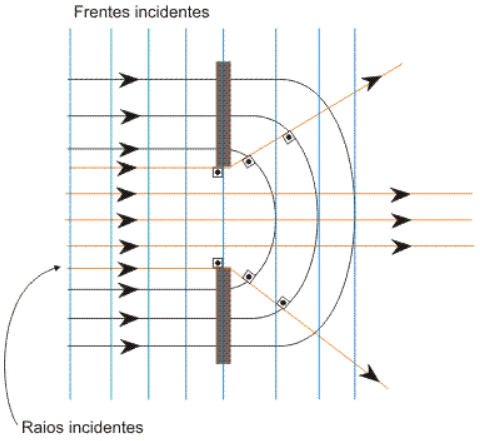
01/11/2023

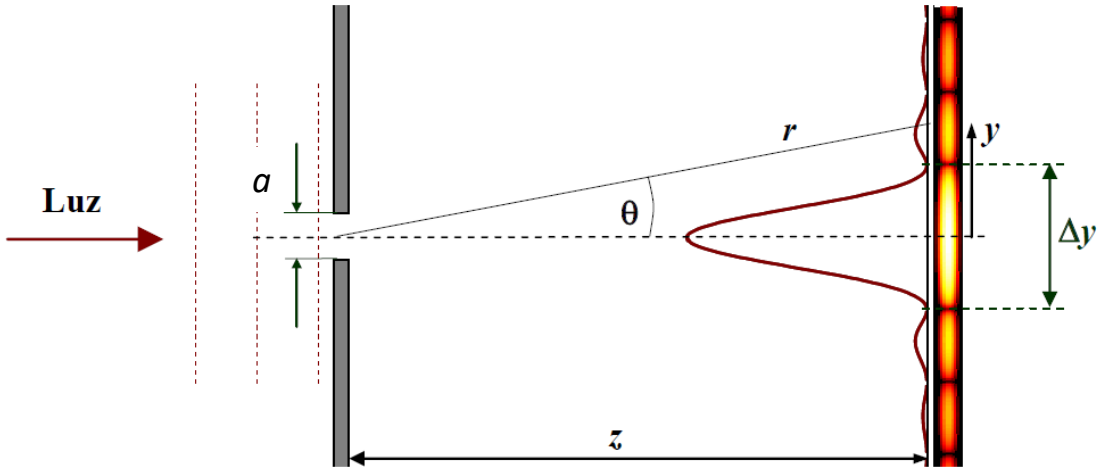
Difração

Fenda pequena



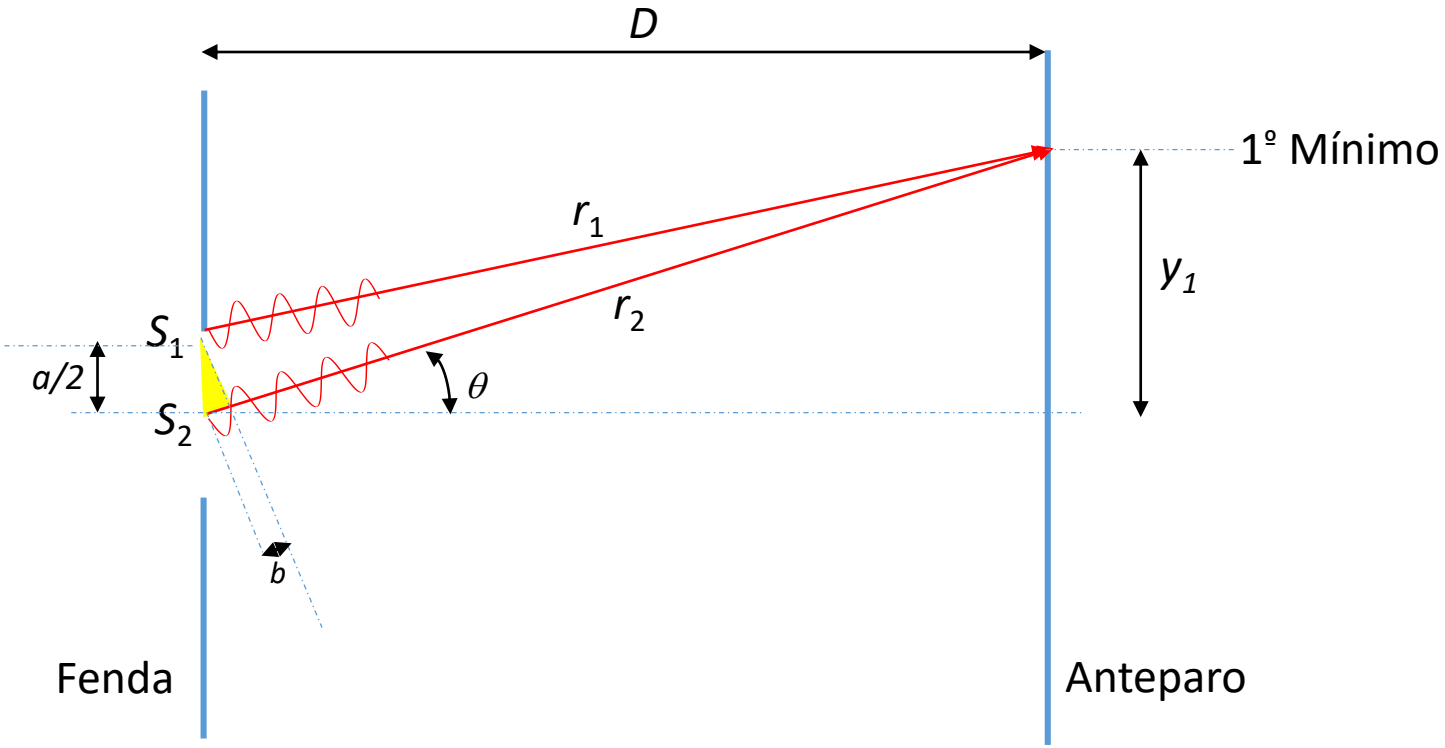
Fenda grande





Difração numa fenda

Dessa forma, pode-se calcular os mínimos, subdividindo a fenda em partes:



Mínimos ocorrem quando $b=\lambda/2$: $sen\theta = \frac{b}{(a/2)} = \frac{2b}{a} = \frac{\lambda}{a}$

$a\ sen\theta = \lambda$ 1º

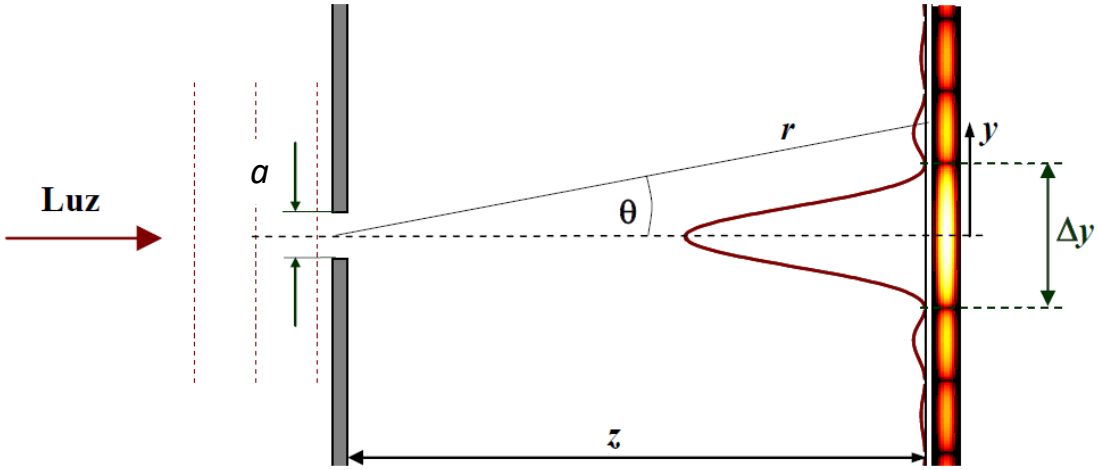
$a\ sen\theta = 2\lambda$ 2º

$a\ sen\theta = 3\lambda$ 3º

...

(m=1,2,3..) $a\ sen\theta = m\lambda$

Difração numa fenda



Normalmente se determina o ângulo de abertura dos dois primeiros mínimos:

$$a\ sen\theta = \lambda \Rightarrow sen\theta = \frac{\lambda}{a} \Leftarrow \theta = arctg\left(\frac{\Delta y}{2z}\right) \Leftarrow tg\theta = \left(\frac{\Delta y/2}{z}\right)$$

Para ângulos pequenos

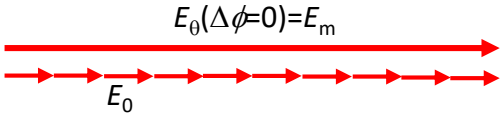
$$\theta \approx \frac{\lambda}{a} \Leftarrow \theta \approx \left(\frac{\Delta y/2}{z}\right)$$

$$\frac{\lambda}{a} = \frac{\Delta y}{2z} \Rightarrow \lambda = \frac{a\Delta y}{2z} \quad \text{ou} \quad a = \frac{2\lambda z}{\Delta y}$$

Difração numa fenda

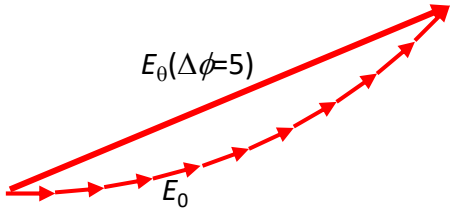
Modelo de Fasor (método geométrico) para determinar o padrão de difração (cálculo quantintativo)

No caso de *m* fontes: Ex: *m*=10

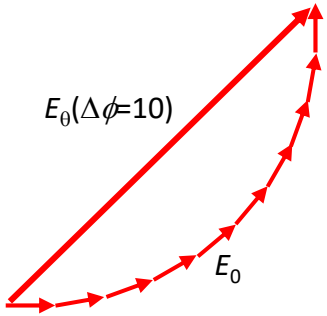


Máximo central, θ=0

Direção θ um pouco fora da central

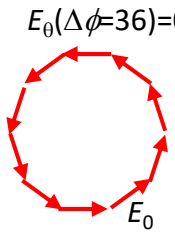


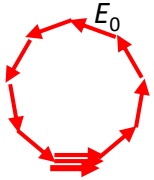
Direção θ um mais fora da central



$$\phi = m\Delta\phi$$

Primeiro mínimo



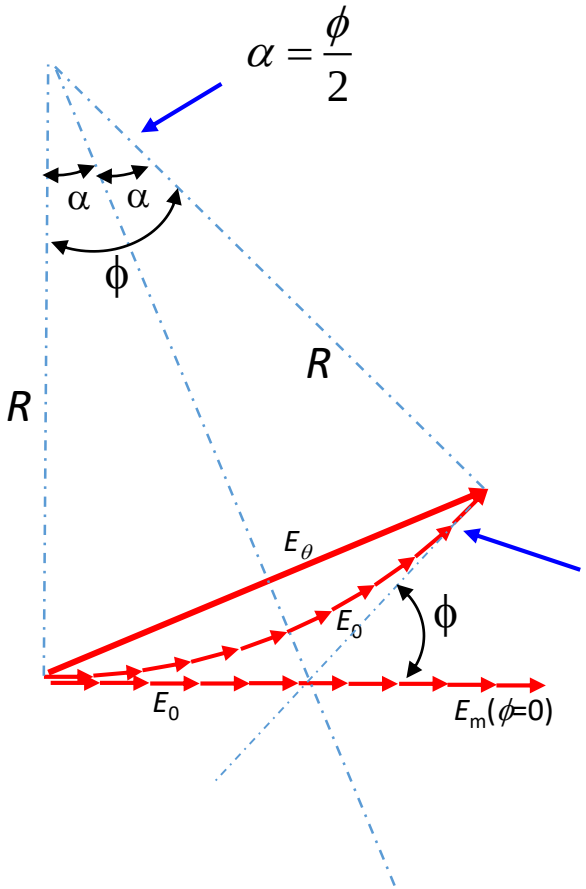


Direção um pouco depois do mínimo

$E_\theta(\Delta\phi=40)=E_0$

Difração numa fenda

Modelo de Fasor (método geométrico) para determinar o padrão de difração (cálculo quantintativo)



$$\alpha = \frac{\phi}{2}$$

$$sen\alpha = \frac{E_\theta / 2}{R} = \frac{E_\theta}{2R} = sen\left(\frac{\phi}{2}\right)$$

$$E_\theta = 2Rsen\left(\frac{\phi}{2}\right)$$

$$\text{Comprimento do arco} = \phi R = E_m \Rightarrow R = \frac{E_m}{\phi}$$

$$E_\theta = \frac{2E_m}{\phi} sen\left(\frac{\phi}{2}\right) = \frac{E_m}{(\phi/2)} sen\left(\frac{\phi}{2}\right)$$

Difração numa fenda

Modelo de Fasor (método geométrico) para determinar o padrão de difração (cálculo quantintativo)

$$E_\theta = \frac{2E_m}{\phi} sen\left(\frac{\phi}{2}\right) = \frac{E_m}{(\phi/2)} sen\left(\frac{\phi}{2}\right)$$

Intensidade é o campo ao quadrado:

$$(E_\theta)^2 = \frac{(E_m)^2}{(\phi/2)^2} sen^2\left(\frac{\phi}{2}\right)$$

$$I = I_m \frac{sen^2\left(\frac{\phi}{2}\right)}{\left(\frac{\phi}{2}\right)^2}$$

$$I = I_m \left(\frac{sen\alpha}{\alpha}\right)^2$$

$$\alpha = \frac{\phi}{2}$$

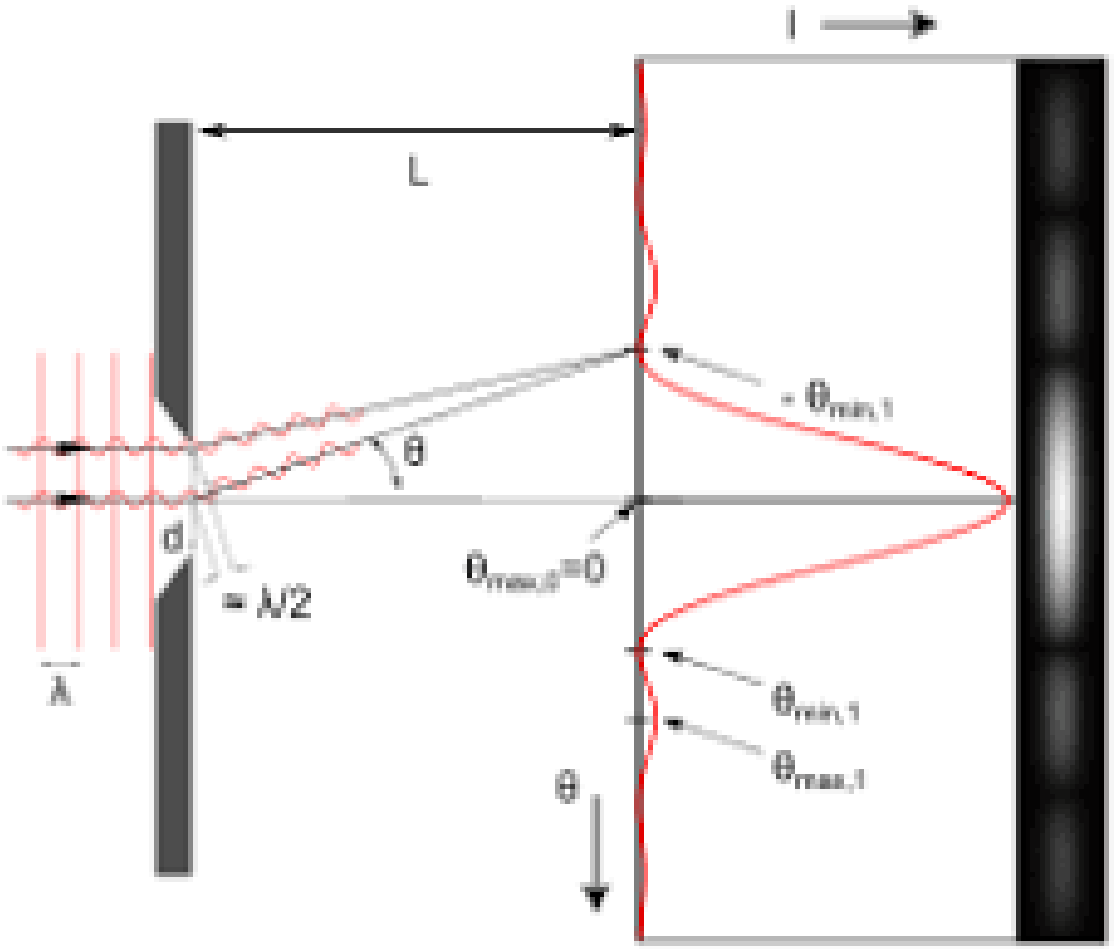
$$\phi = \left(\frac{2\pi a}{\lambda}\right) sen\theta$$

$$\frac{\phi}{2} = \left(\frac{\pi a}{\lambda}\right) sen\theta$$

Difração numa fenda

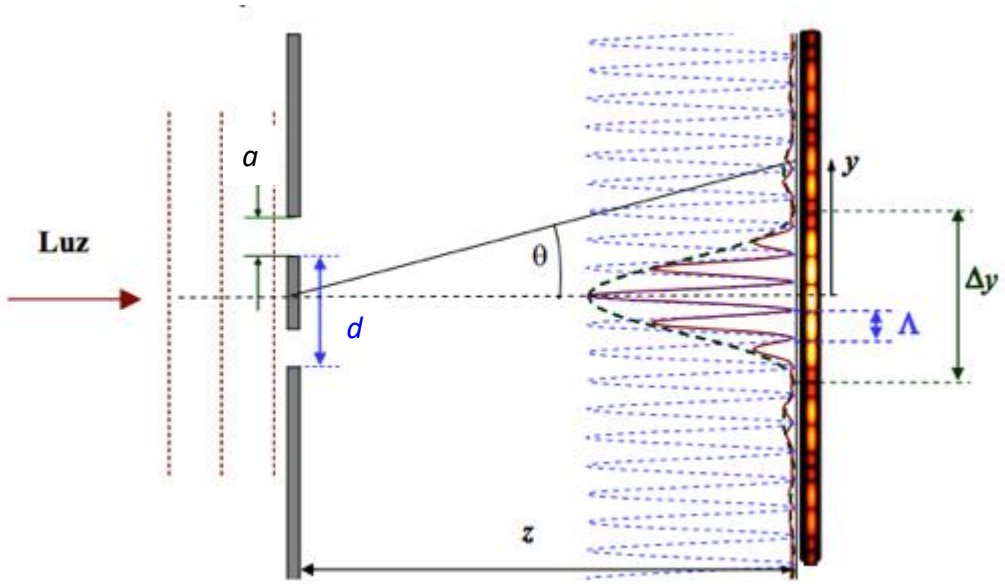
$$I = I_m \left(\frac{sen\alpha}{\alpha} \right)^2$$

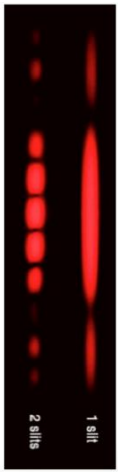
$$\alpha = \frac{\phi}{2} = \left(\frac{\pi a}{\lambda} \right) sen\theta$$



Difração na Dupla Fenda

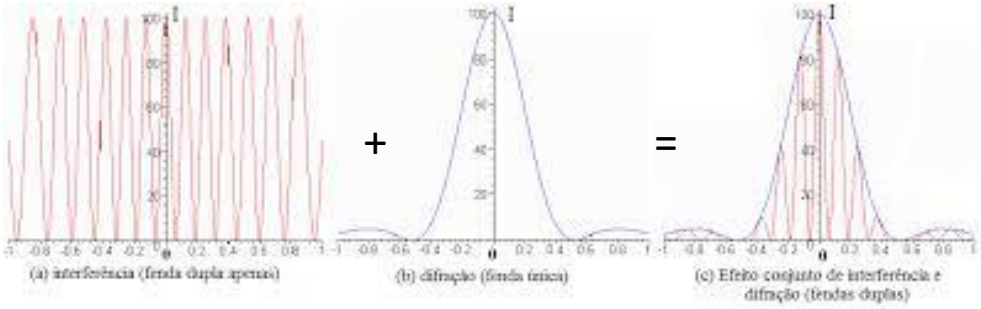
Experimento de Young





interferência

difração

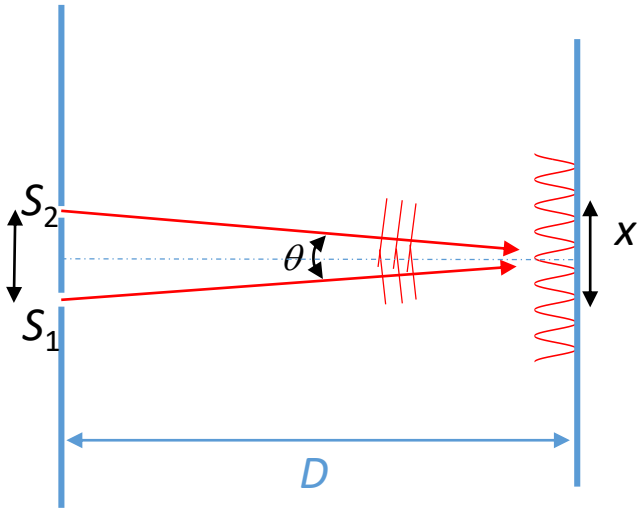


$$I = I_0 \left(\cos^2 \beta\right)\left(\frac{sen\alpha}{\alpha}\right)^2$$

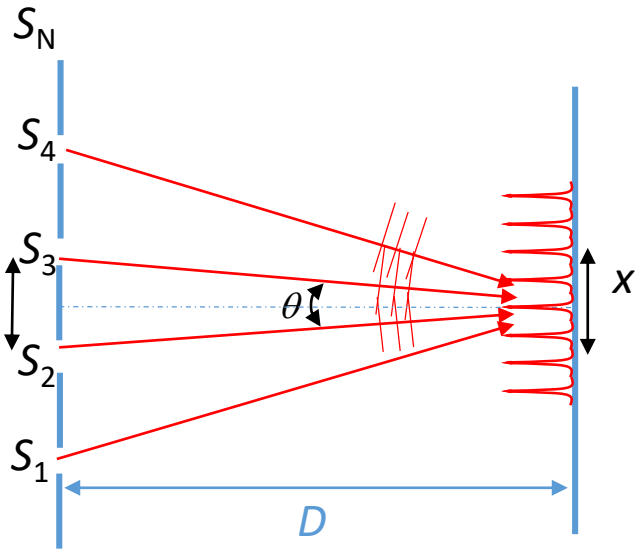
$$\beta = \frac{\pi d}{\lambda} sen\theta$$

$$\alpha = \left(\frac{\pi a}{\lambda}\right) sen\theta$$

O que acontece se tiver mais de duas fendas?



$$I = E^2 = 4I_0 \cos^2(\beta)$$



A interferência de múltiplos feixe leva ao estreitamento dos picos de máximos !

$$\left| \sum_{j=0}^{N} \exp(ijk_x d) \right| = \left(\frac{sen^2(Nk_x d/2)}{sen^2(k_x d/2)} \right)$$

$$I = I_0 \left(\frac{sen^2 N\beta}{sen^2 \beta} \right)$$

O que acontece se tiver mais de duas fendas?

$$I = I_0 \left(\frac{sen^2 N\beta}{sen^2 \beta} \right)$$

N=2

$$I = I_0 \left(\frac{sen^2 2\beta}{sen^2 \beta} \right)$$

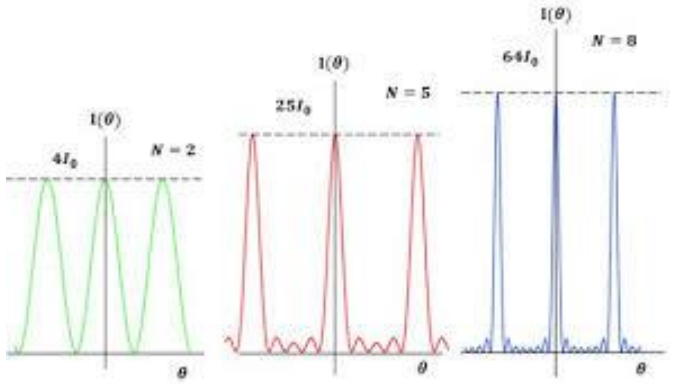
$$I = I_0 \left(\frac{(2sen\beta \cos\beta)^2}{sen^2 \beta} \right)$$

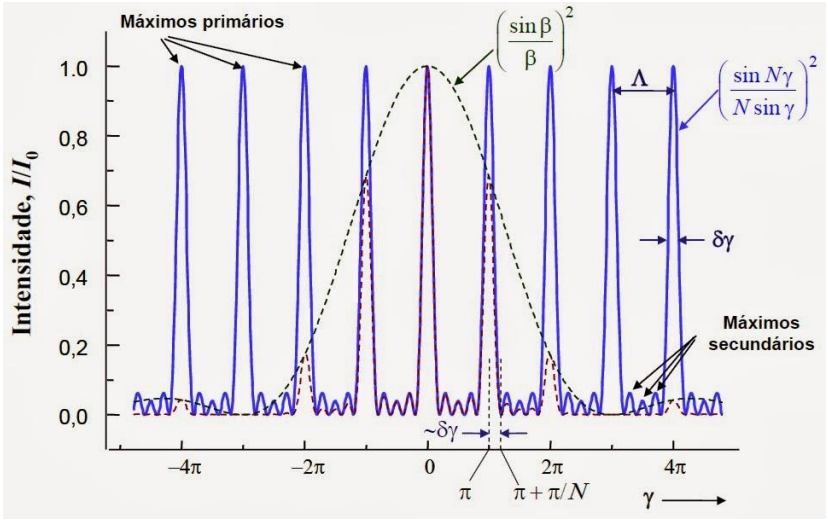
$$I = I_0 \left(\frac{4sen^2 \beta \cos^2 \beta}{sen^2 \beta} \right)$$

$$I = 4I_0 \cos^2 \beta$$

Difração em Múltiplas Fendas

Princípio da superposição de várias ondas:





$$I = I_0\left(\cos^2\beta\right)\left(\frac{sen\alpha}{\alpha}\right)^2$$

2 Fendas

$$I = I_0\left(\frac{sen^2 N\beta}{sen^2\beta}\right)\left(\frac{sen\alpha}{\alpha}\right)^2$$

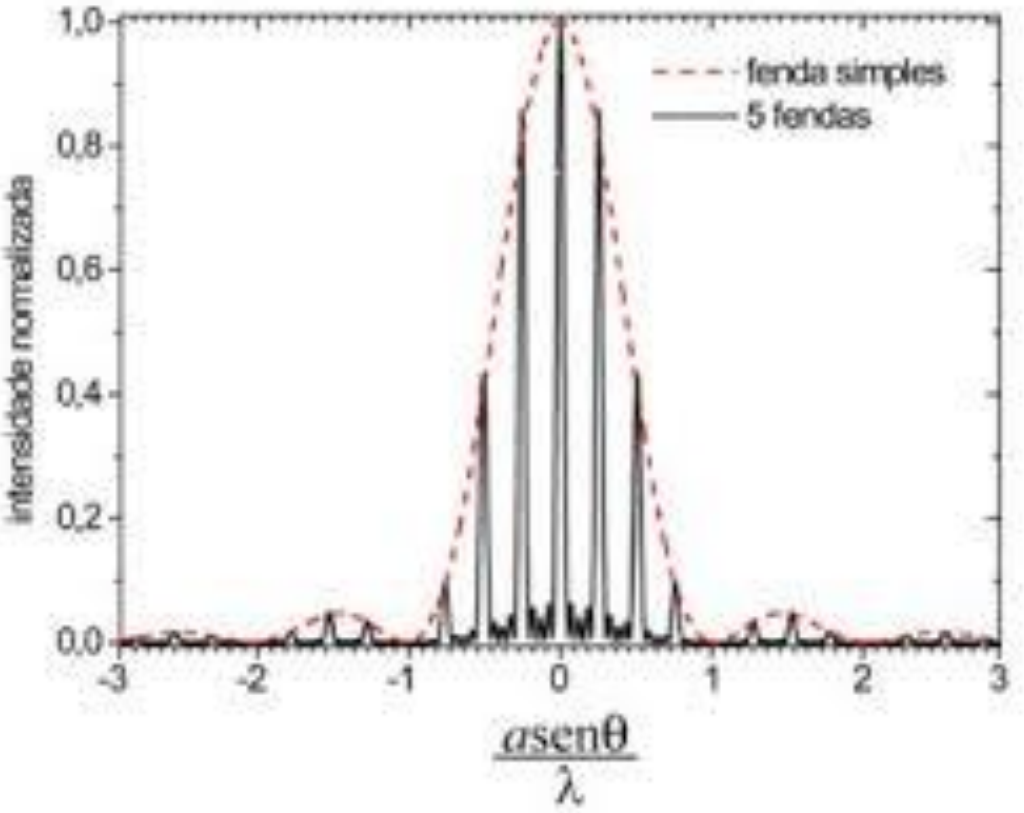
N Fendas

$$\beta = \frac{\pi d}{\lambda} sen\theta$$

$$\alpha = \left(\frac{\pi a}{\lambda}\right) sen\theta$$

Difração em Múltiplas Fendas

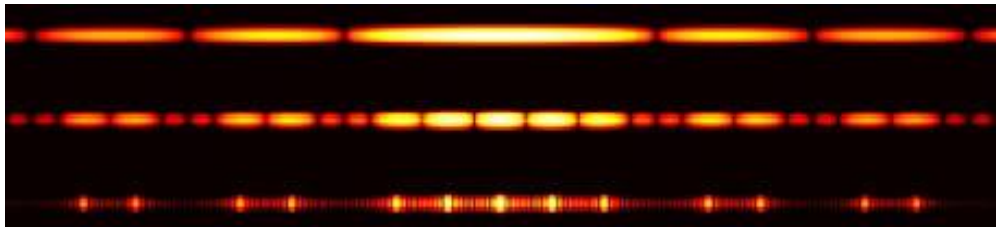
Rede de difração



$$I = I_0 \left(\frac{sen^2 N\beta}{sen^2 \beta} \right) \left(\frac{sen\alpha}{\alpha} \right)^2$$

$$\beta = \frac{\pi d}{\lambda} sen\theta$$

$$\alpha = \left(\frac{\pi a}{\lambda} \right) sen\theta$$



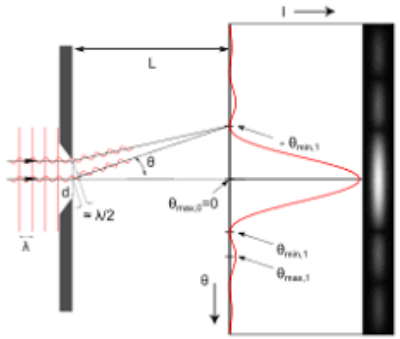
N=1 (uma fenda)

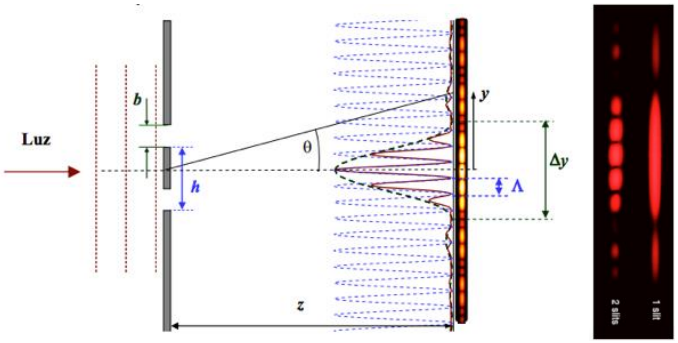
N=2 (uma fenda)

N=5 (uma fenda)

Experimento

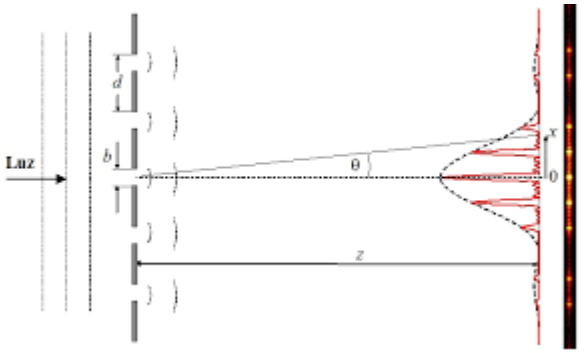
1-) Difração em um fenda simples





2-) Difração em uma fenda dupla

3-) Difração em uma rede de difração



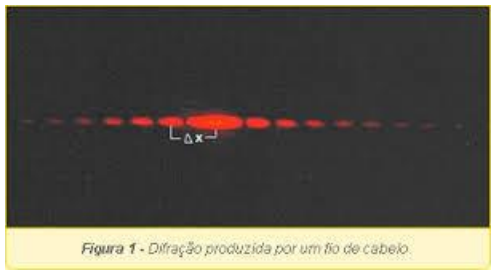
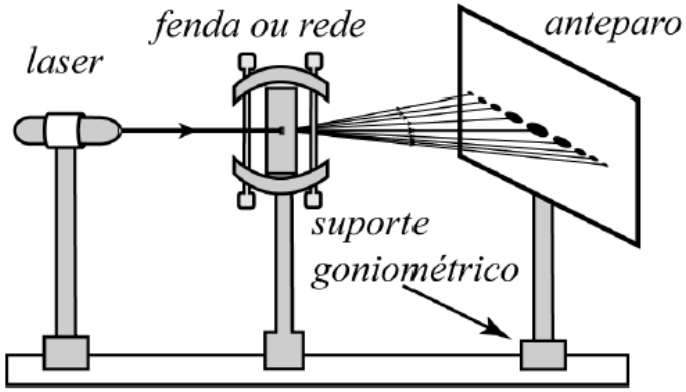


Figura 1 - Difração produzida por um fio de cabelo.

4-) Difração em um fio de cabelo

Experimento



Esquema experimental para toda a prática