SLC 642 – Laboratório de Óptica

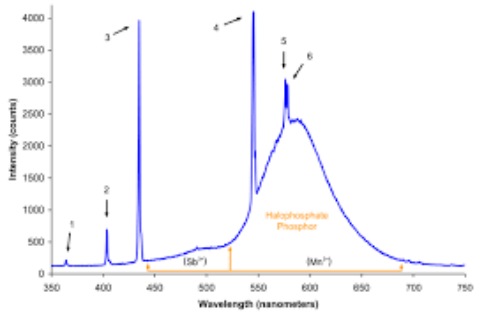
Licenciatura em Ciências Exatas – São Carlos

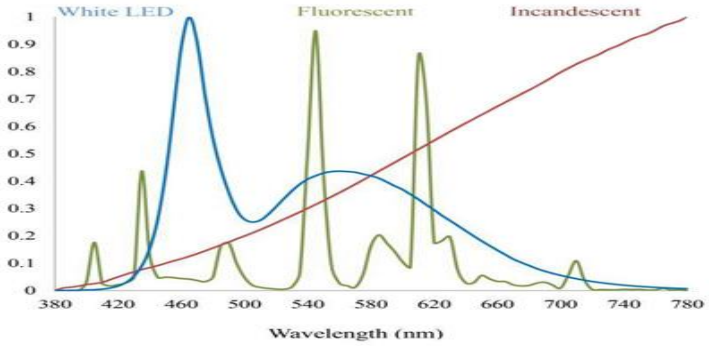
Prática 6:
Espectroscopia Óptica

22/11/2023

Espectroscopia óptica

Espectro de emissão

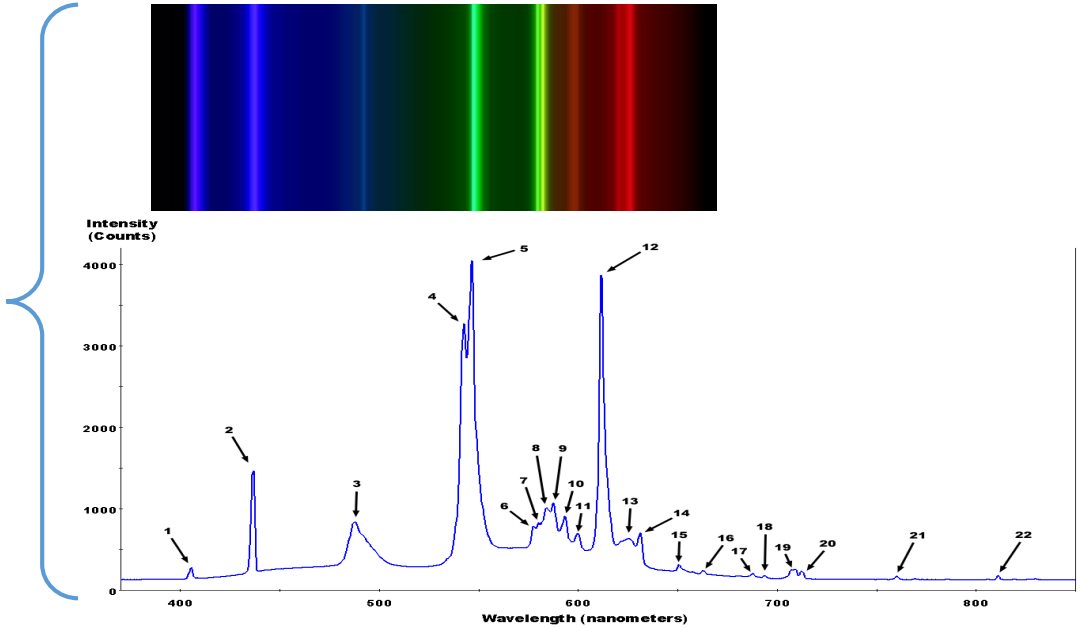




Luz branca contínua: Lâmpadas convencionais, lâmpada fluorescente, LED branco, sol, etc.

Espectroscopia óptica

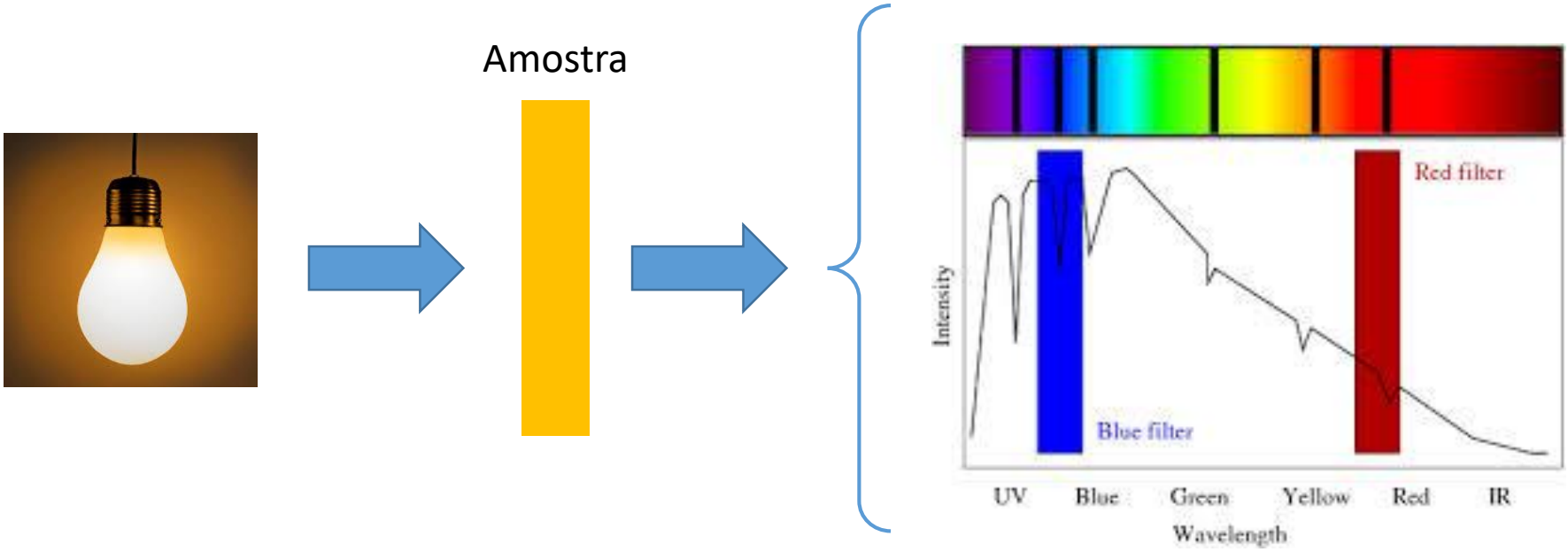
Espectro de emissão



Lâmpadas espectrais:
Mercúrio, Sódio, Cádmio, Neônio, Hidrogênio,
Hélio, etc.

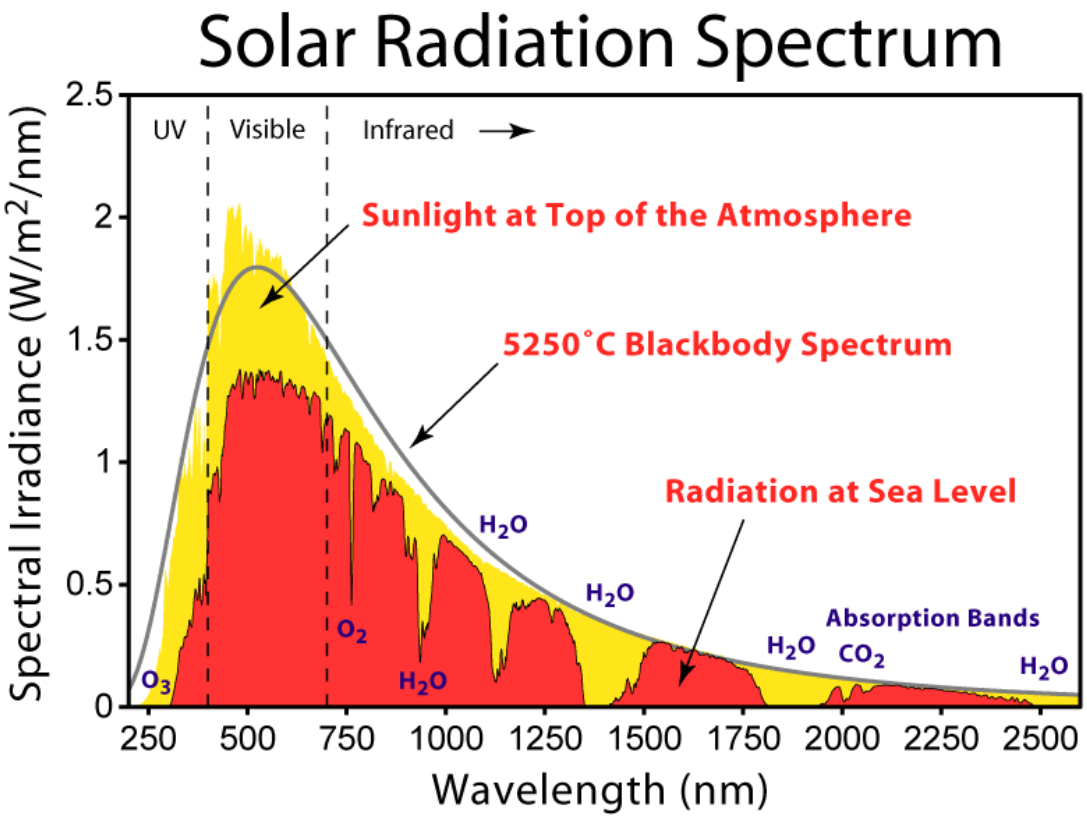
Espectroscopia óptica

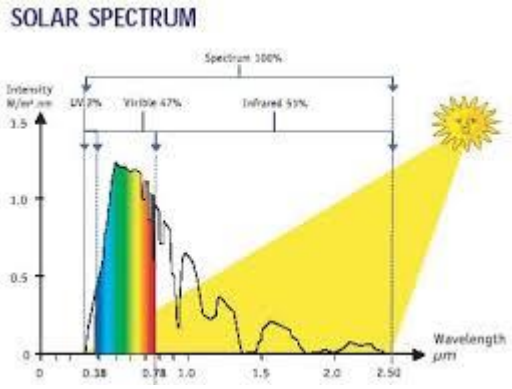
Espectro de absorção



Diferentes amostras tem diferentes espectros de absorção

Espectroscopia óptica

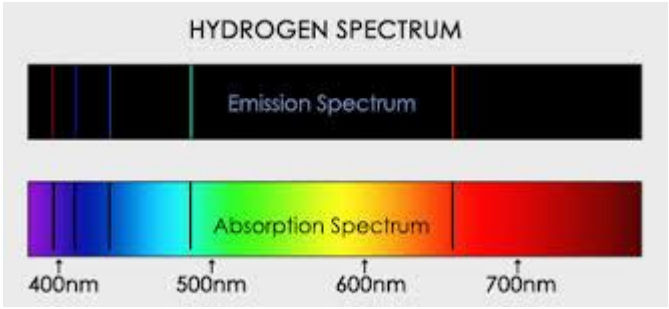


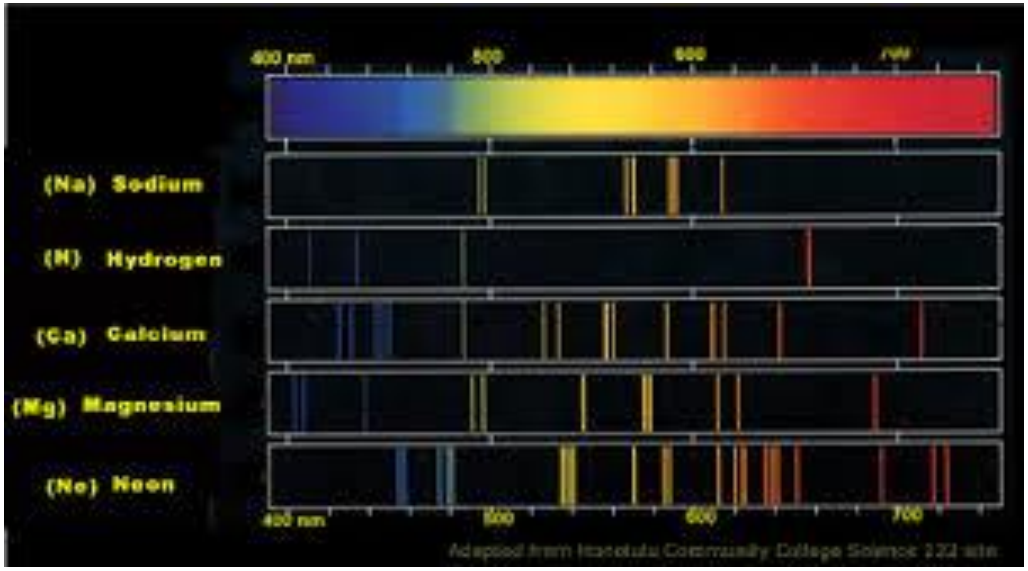


Uma grande fração do espectro solar não é visível!

Espectroscopia óptica

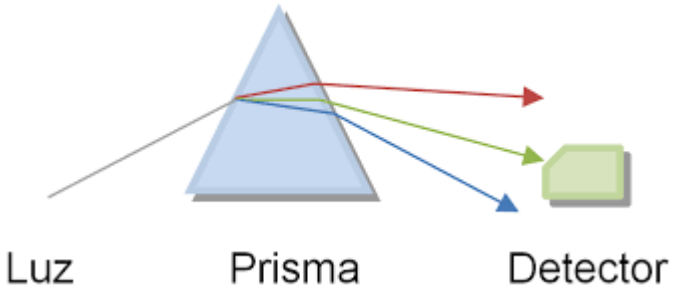
Espectro de emissão e absorção são correlatas





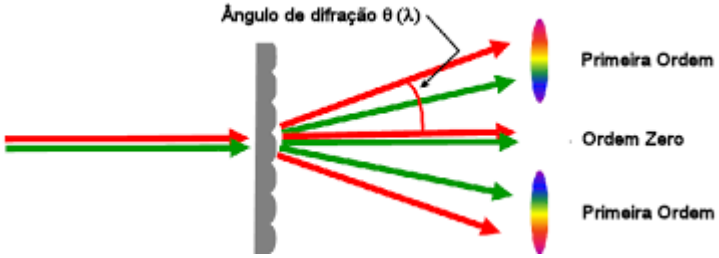
Espectroscopia óptica

Para fazer espectroscopia óptica é preciso tem um instrumento que dispersa a luz

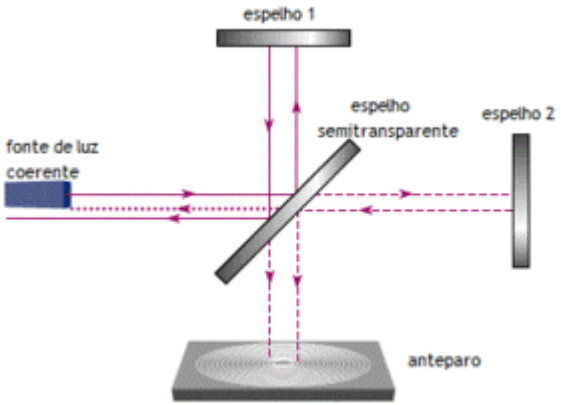


Prisma

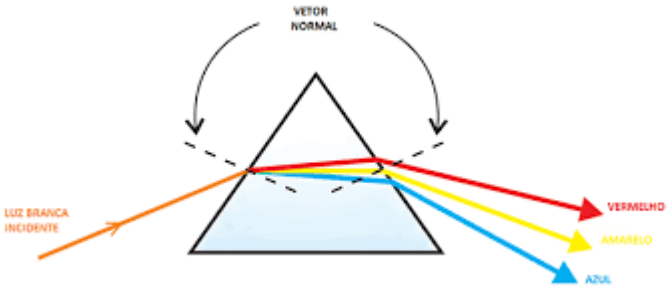
Rede de difração



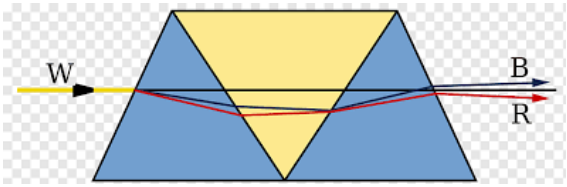
Interferômetro



Prisma



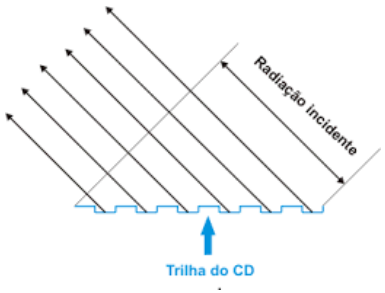
Prisma de Amici



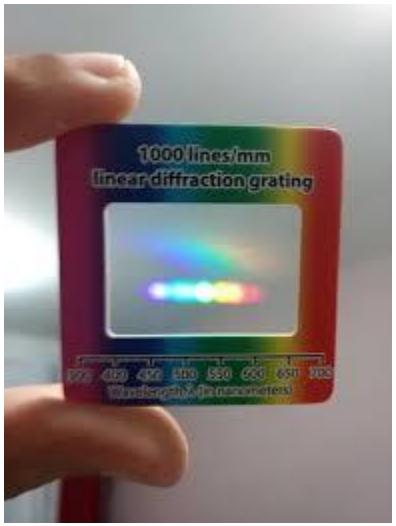
Rede de Difração

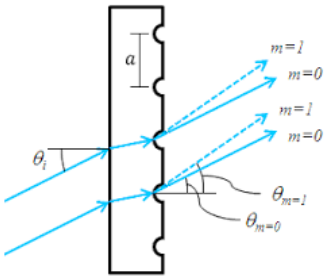
Muito mais poder de dispersão!

CD

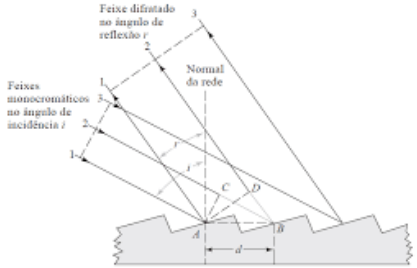


Rede de difração por transmissão

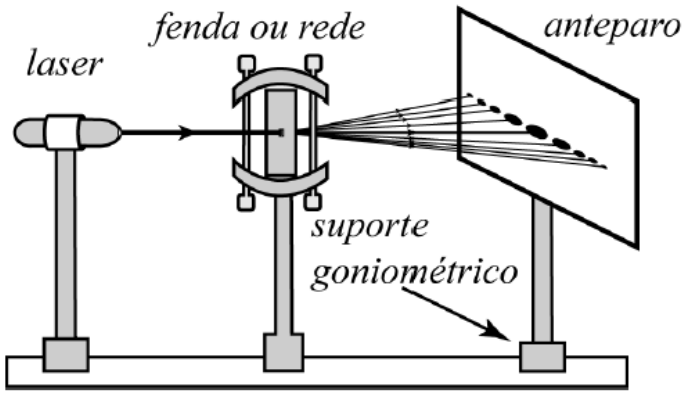




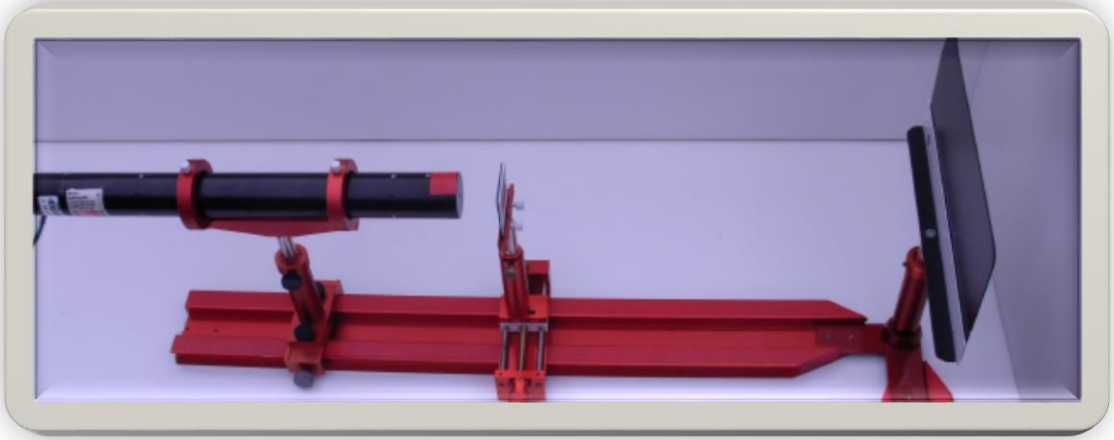
Rede de difração por reflexão



Fonte de luz colimada: Laser

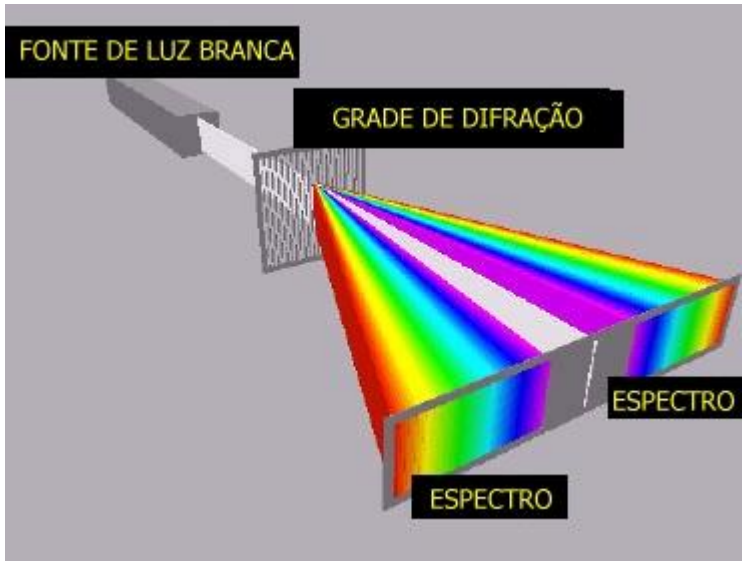


Esquema experimental para toda a prática



Espectrômetro

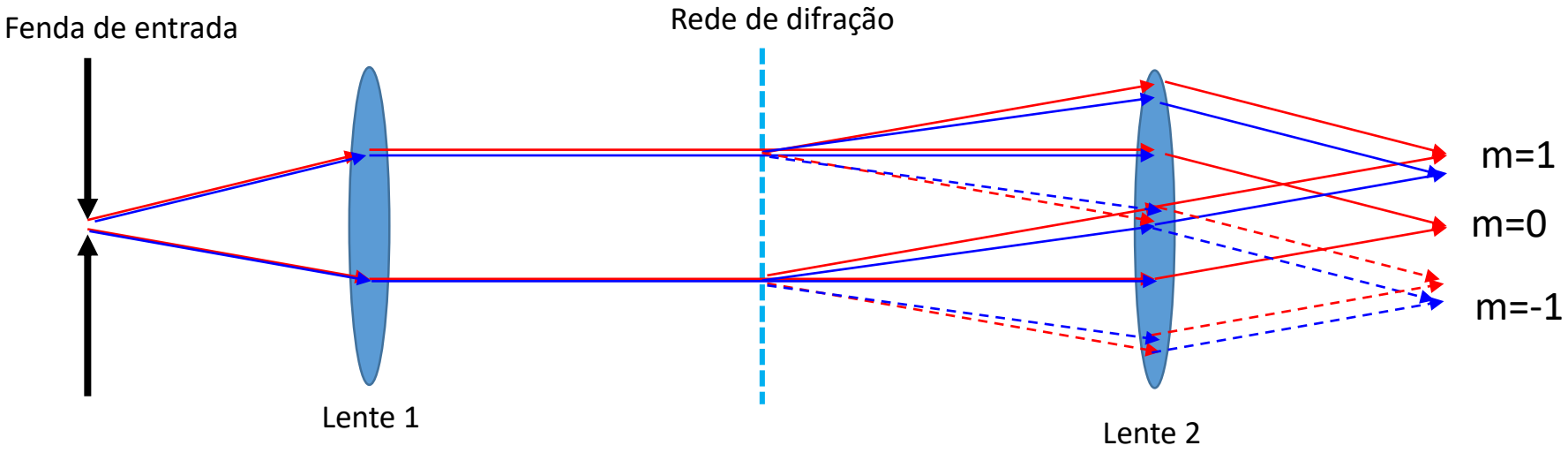
No caso de fonte de luz extensa: Uso de fendas



Necessita o uso de um Telescópio

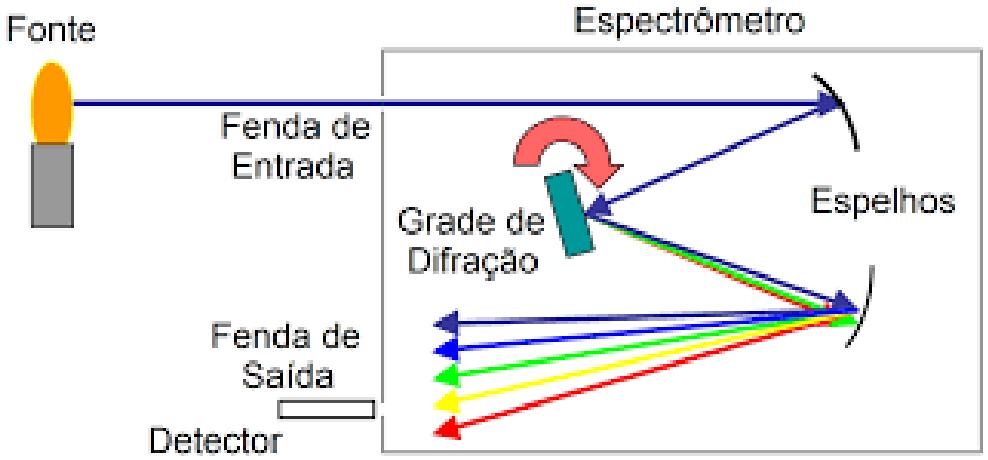
Espectrômetro

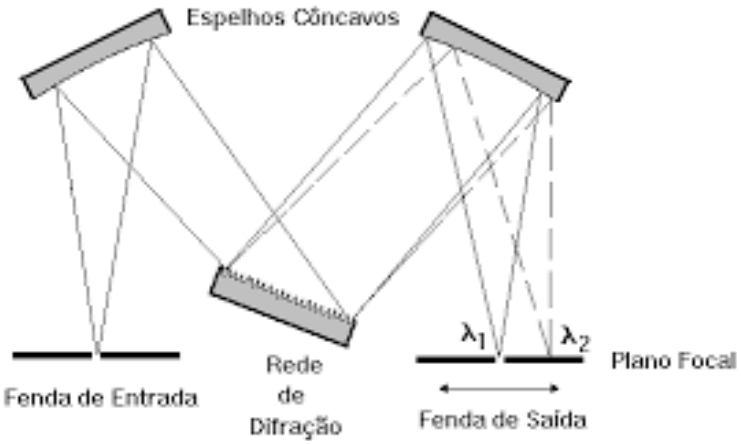
O telescópio composto das lente 1 e 2 projeta a imagem da fenda de entrada



Espectrômetro

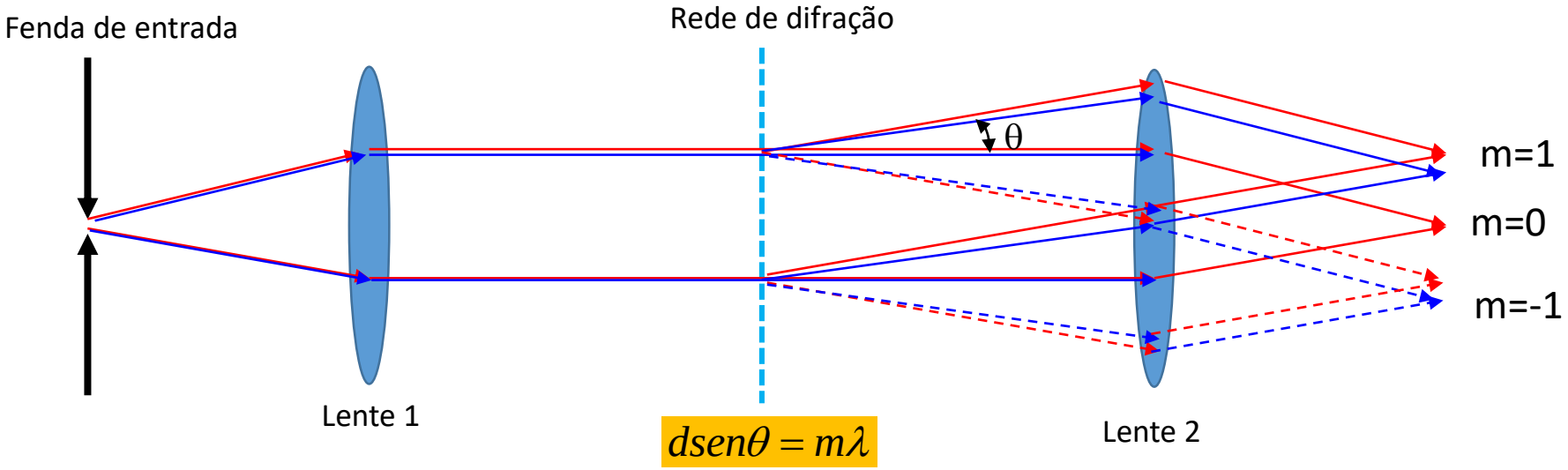
Espectrômetro comerciais usam espelhos e redes de difração reflexivas





Espectrômetro

Rede de difração: Linhas/mm $\Rightarrow$ *d* (espaçamento entre as linhas)



$$dsen\theta = m\lambda$$

$$\partial(dsen\theta) = \partial(m\lambda)$$

$$d\partial(sen\theta) = m\partial\lambda$$

$$d\cos\theta\partial\theta = m\partial\lambda$$

$$\frac{\partial\theta}{\partial\lambda} = \frac{m}{d\cos\theta}$$

Dispersão

$$Disp = \frac{m}{d\cos\theta}$$

Ordem -1 Ordem +1

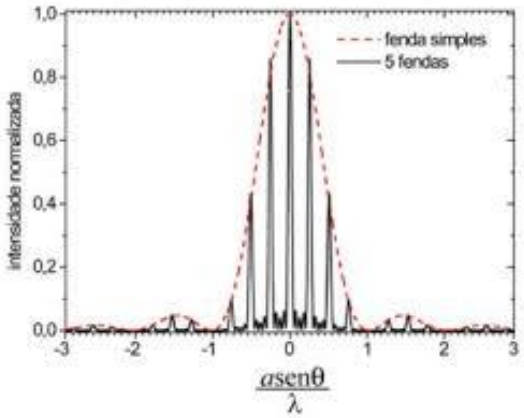
Espectrômetro

Rede de difração: Linhas/mm $\Rightarrow$ *d* (espaçamento entre as linhas)

Ordem -1 Ordem +1

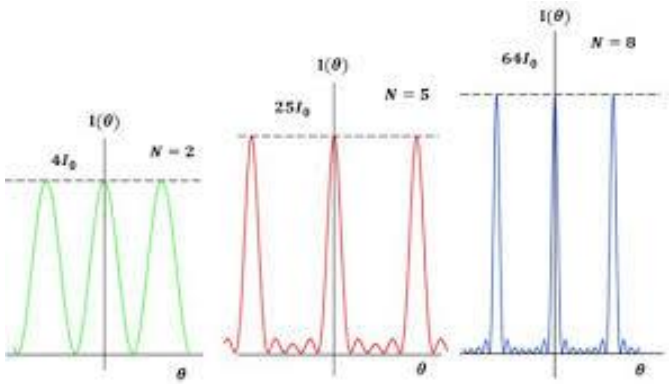
Resolução

Largura das linhas
(proporcional a N)



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

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



Espectrômetro

Rede de difração: Linhas/mm $\Rightarrow$ *d* (espaçamento entre as linhas)

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

=0 ($N\beta = \pm\pi$)

$\beta = \pm\pi/N$

$$\delta\beta = \partial\beta = \frac{\pi}{N}$$

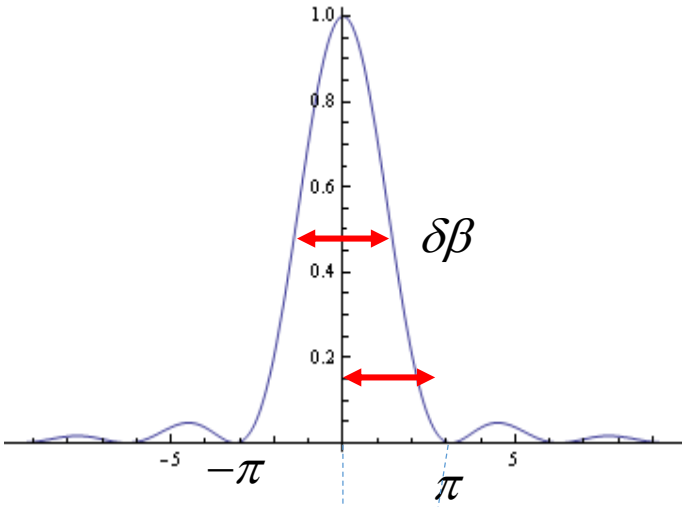
$$\beta = \frac{\pi d}{\lambda} sen\theta$$

$$\partial(\beta) = \partial\left(\frac{\pi d}{\lambda} sen\theta \right)$$

$$\partial\beta = \frac{\pi d}{\lambda} \partial(sen\theta) = \frac{\pi d}{\lambda} \cos\theta \partial\theta$$

$$\partial\theta = \frac{\lambda}{\pi d \cos\theta} \partial\beta = \frac{\lambda}{\pi d \cos\theta} \frac{\pi}{N}$$

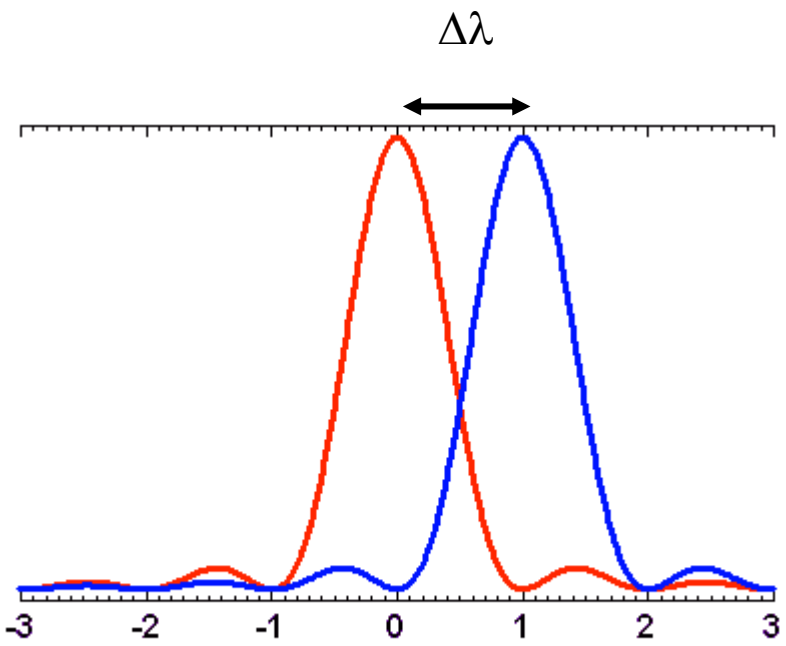
$$\partial\theta = \frac{\lambda}{Nd \cos\theta}$$



Rede de Difração

Coincide com o Critério de Rayleigh

Separação mínima entre dois comprimentos de ondas



$$sen\theta = m\frac{\lambda}{d}$$

$$\partial\left(sen\theta\right) = m\partial\left(\frac{\lambda}{d}\right)$$

$$\cos\theta\partial\theta = m\frac{\partial\lambda}{d}$$

$$\partial\lambda = \frac{d\left(\cos\theta\right)\partial\theta}{m}$$

$$sen\theta = m\frac{\lambda}{a}$$

$a \Leftrightarrow d$

Espectrômetro

$$\partial\theta = \frac{\lambda}{Nd\cos\theta} \quad \Rightarrow \quad \lambda = \partial\theta\left(Nd\cos\theta\right)$$

(Critério de Rayleigh) $\Rightarrow$ $\partial\lambda = \frac{d\left(\cos\theta\right)\partial\theta}{m}$

Resolução

$$R = \frac{\lambda}{\delta\lambda} \quad \Rightarrow \quad \frac{\lambda}{\delta\lambda} = \frac{\partial\theta\left(Nd\cos\theta\right)}{d\cos\theta\partial\theta / m} = Nm = R$$

$$R = Nm$$

Experimento

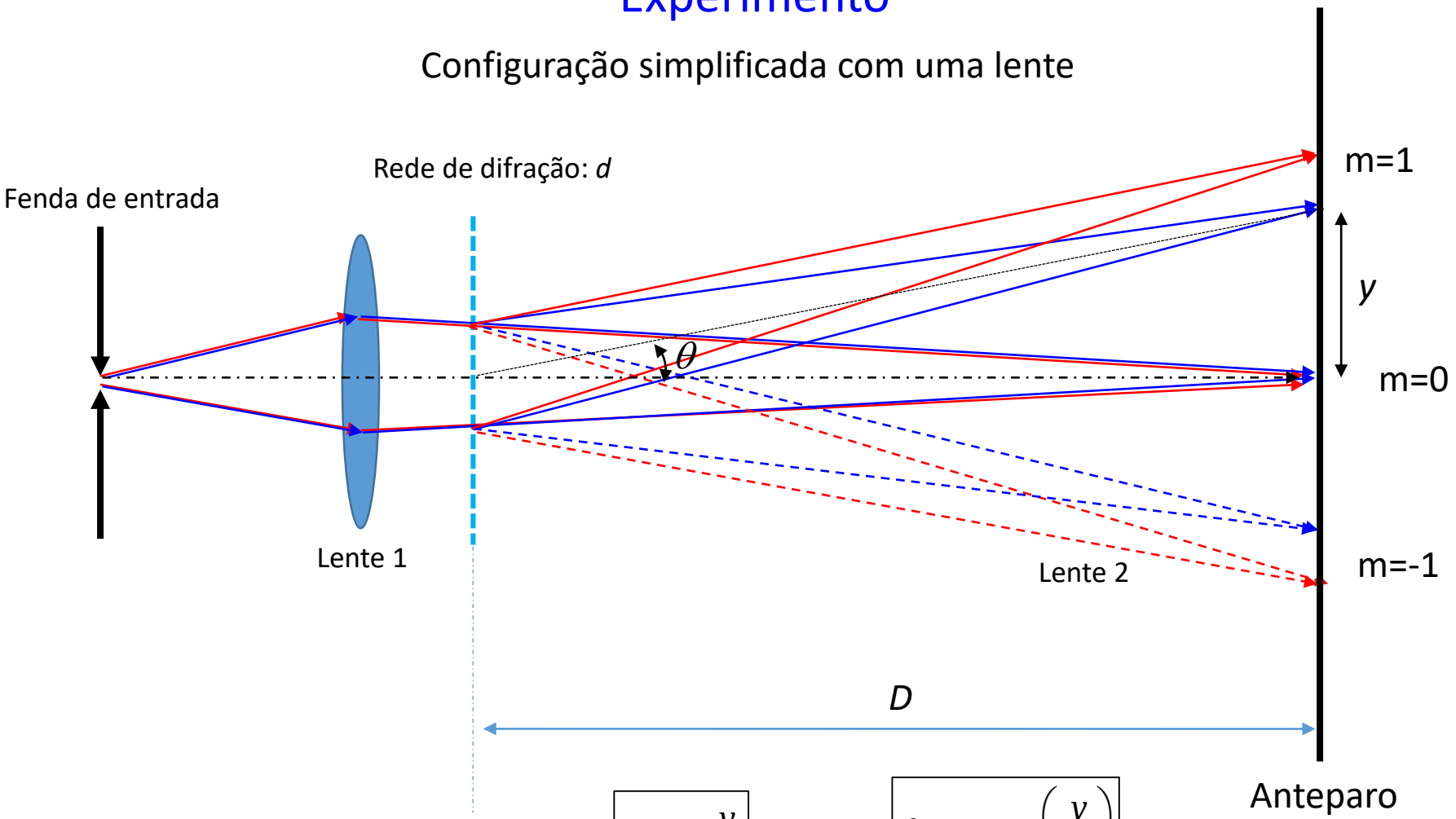
1- Espectro de emissão da lâmpada de mercúrio

2- Espectro de emissão lâmpada de vapor de sódio

3- Espectro de absorção de uma solução com terra rara

Experimento

Configuração simplificada com uma lente

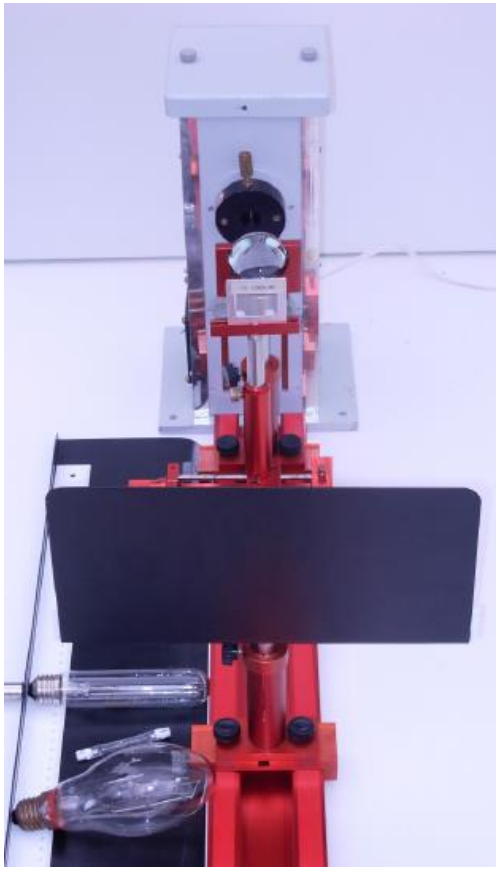


$$tg\theta = \frac{y}{D} \Rightarrow \theta = arctg\left(\frac{y}{D}\right)$$

$$dsen\theta = m\lambda \Rightarrow \lambda = \frac{dsen\theta}{m}$$

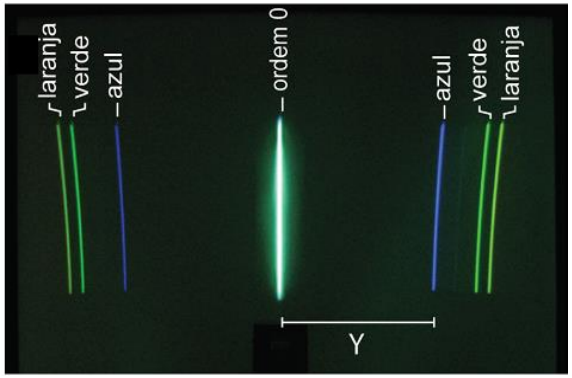
Experimento

Espectro de emissão: Lâmpada de mercúrio e de sódio



Rede de difração: 300 e 600 linhas/mm

Lâmpada de Mercúrio



Experimento

Espectro de absorção: Solução com neodímio e európio

Luz branca