Physics 114 - April 8, 2010

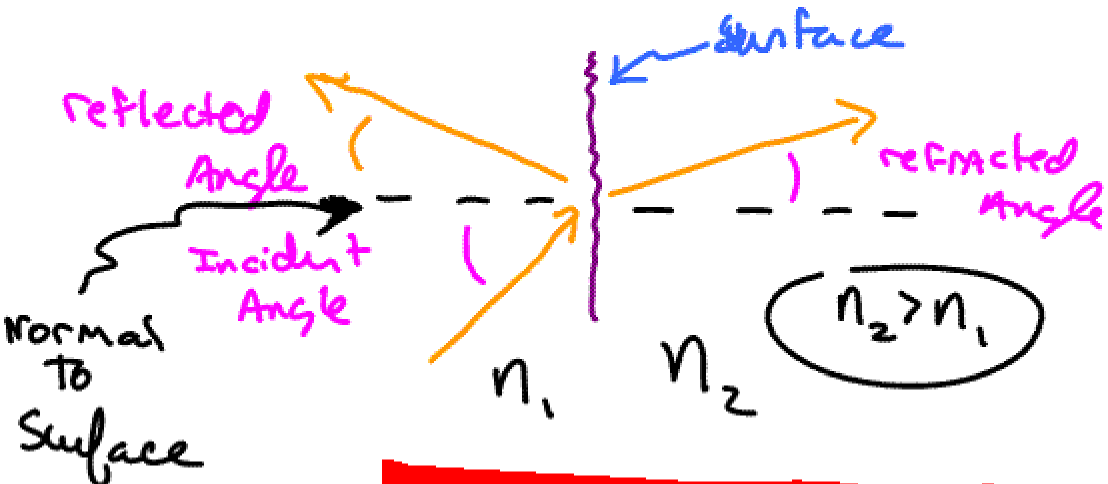
- Sent out email about Exam
- Q+A session - possible ...
- Yes - will have workshops next week
- No P.S. due next week

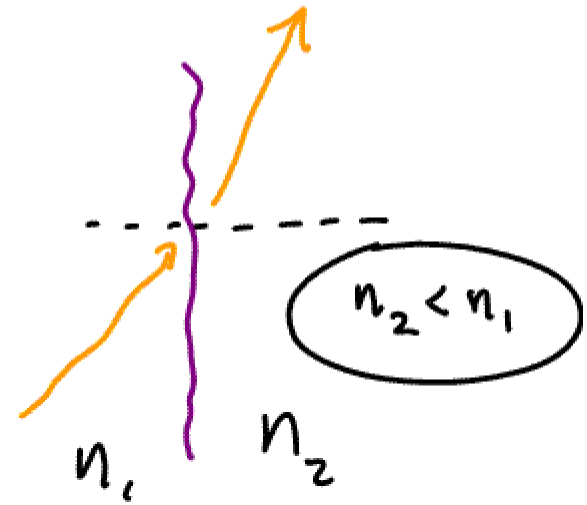
  ... but quite the whopper for the following week

Last Time

Geometric Optics

$n = c/v \equiv$ index of Refraction





Snell's law

$$\boxed{n_1 \sin\theta_1 = n_2 \sin\theta_2}$$

Critical Angle $\equiv \theta_c \longrightarrow$ Angle of Inc. when Angle of refr. is $90°$

$\theta_I > \theta_c \longrightarrow$ Total internal reflection

n depends on ν $\Rightarrow$ bending depends on ν

Dispersion , Prisms

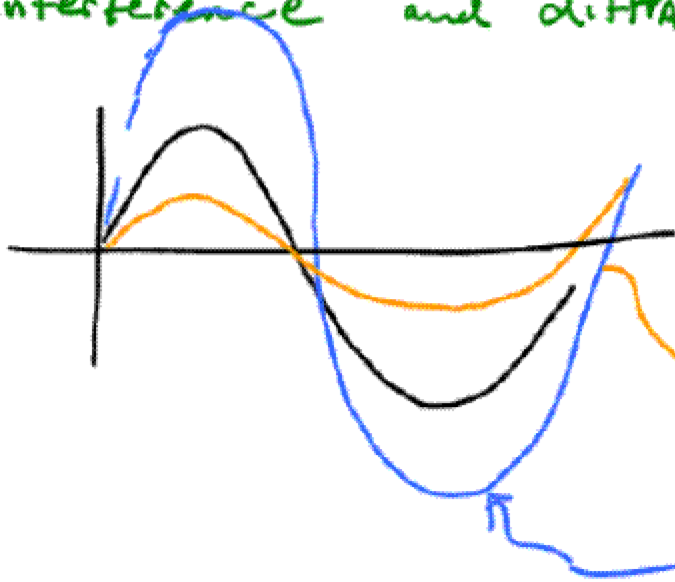
Then went thru thin lenses

$\Big\downarrow$ See other file -

- Do Snell's law Java applet
- Do thin lens applet

Physical Optics

Interference and diffraction



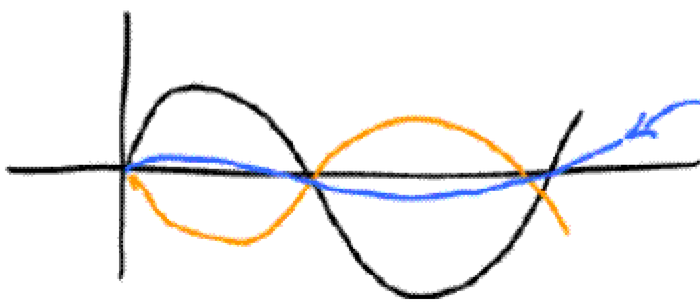
$$\vec{E}_1 = \vec{E}_{01} \sin(\omega t - kz)$$

$$\vec{E}_2 = \vec{E}_{02} \sin(\omega t - kz + \delta)$$

$\delta = 0$ in phase

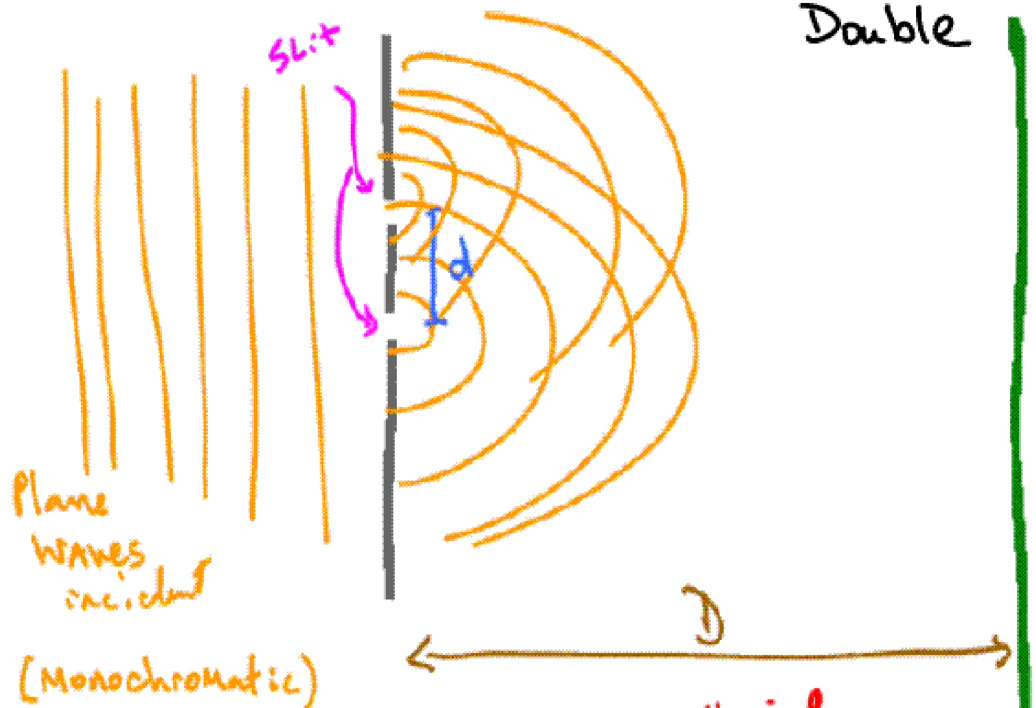
$=$ constructive interference

if $\delta = \pi$

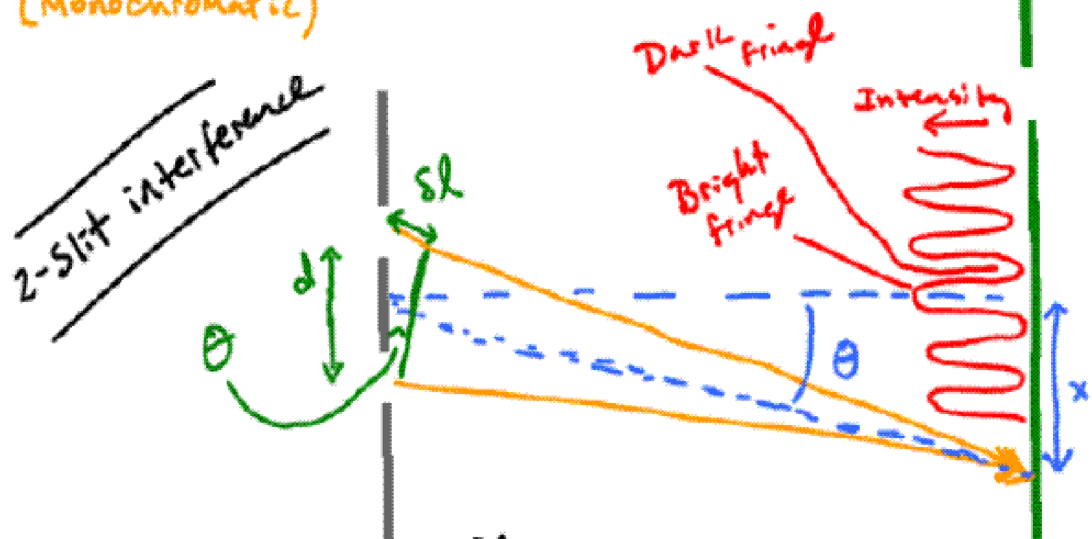


Destructive interference

Double Slit interference



Look at intensity Pattern of the light on screen

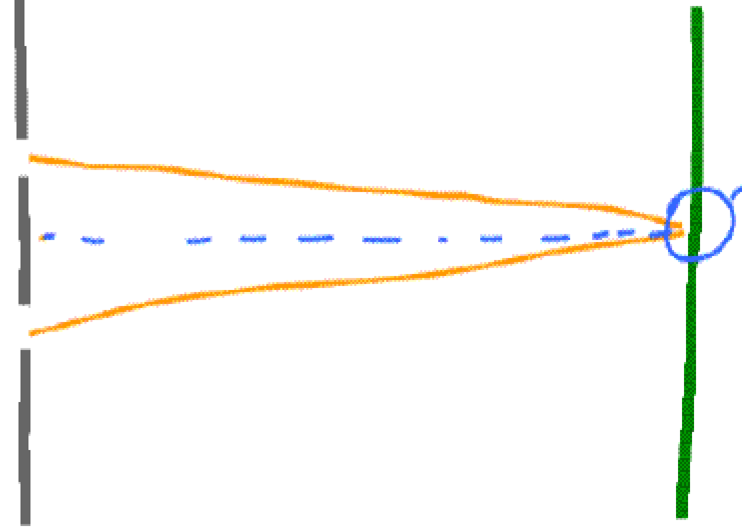


Expect "interference Pattern" in intensity of light on screen

$$\tan\theta = \frac{x}{d}$$

$$\frac{\delta l}{d} = \sin\theta$$

$$\delta l = d\sin\theta$$



Constructive Interference

$$\delta l = m\lambda \qquad m = 0, 1, 2 \cdots$$

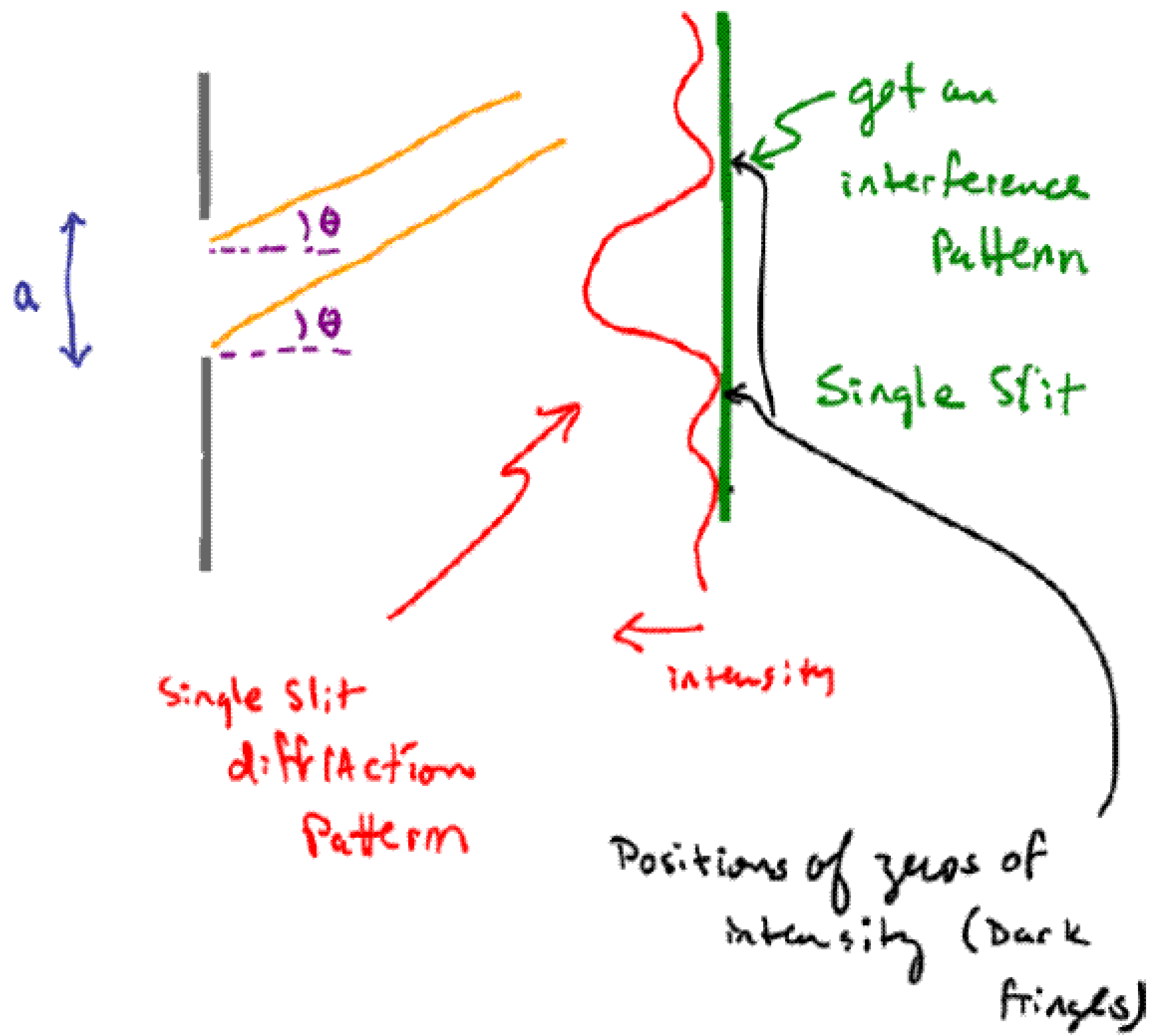
bright fringes on screen

$$d \sin\theta = m\lambda$$

destructive Interference

$$d \sin\theta = \left(m + \tfrac{1}{2}\right)\lambda \qquad m = 0, 1, 2 \ldots$$

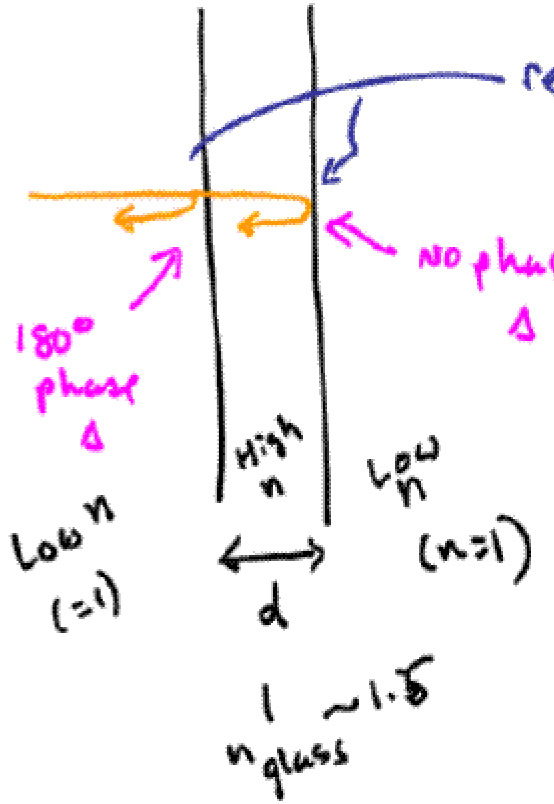
Single Slit Diffraction



$$\sin\theta = \frac{\lambda}{a}$$

Thin film interference

$n \equiv$ index of refraction $= \frac{c}{v}$



reflected light from the two interfaces interferes

- Oil on water
- Anti-reflective coatings

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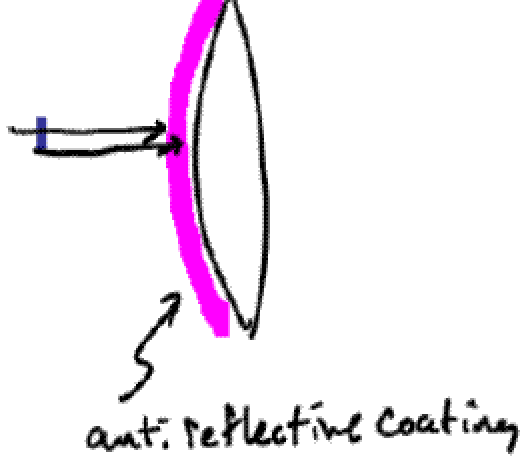
High n to low n ⇒ no phase change upon reflection

Low n to High n ⇒ 180° phase change upon reflection



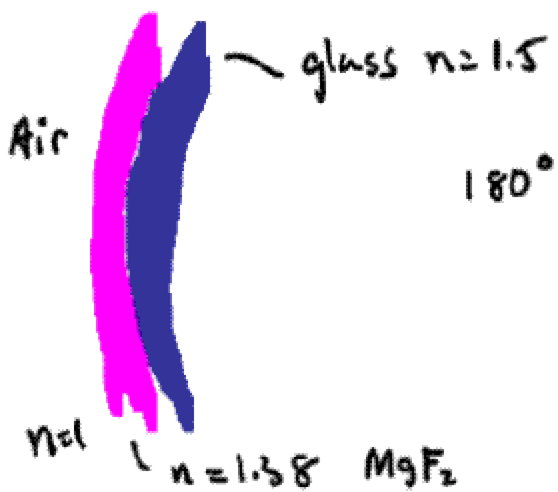
coating MgF_2

reduce reflection

camera lens

central $\lambda = 550\,nm$)
(visible)

How thick should coating be to minimize reflection at $\lambda = 550$



180° phase Δ at Both interfaces

$m = 0, 1, 2 \ldots$

Minimum (Destruct) $2d = (m+\frac{1}{2})\lambda_n$ $\lambda_n = \lambda/n$

Thinnest possible film

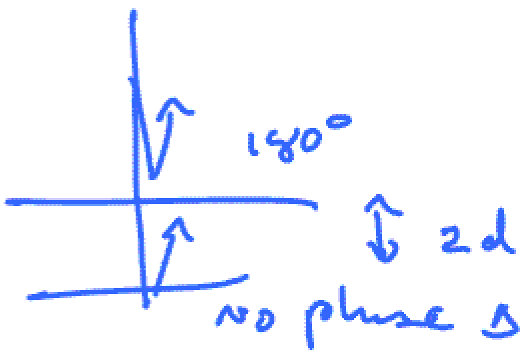
constructive Int

$$2d = (m + \tfrac{1}{2})\lambda_n$$

$m = 0$

$$2d = \tfrac{1}{2}\lambda_n = \tfrac{1}{2}\frac{\lambda}{n}$$

$$d = \frac{\lambda}{4n} = 100\ \text{nm}$$

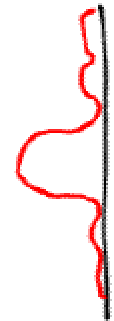


$$2d = (m + \tfrac{1}{2})\underbrace{\lambda_n}$$

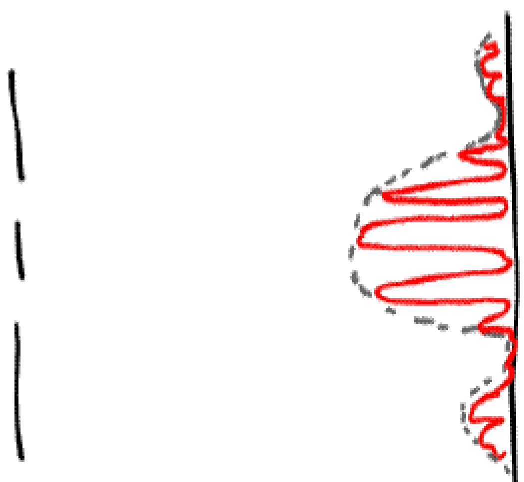
λ/n

Return to Diffraction

2-slit int pattern



single Slit Diffraction



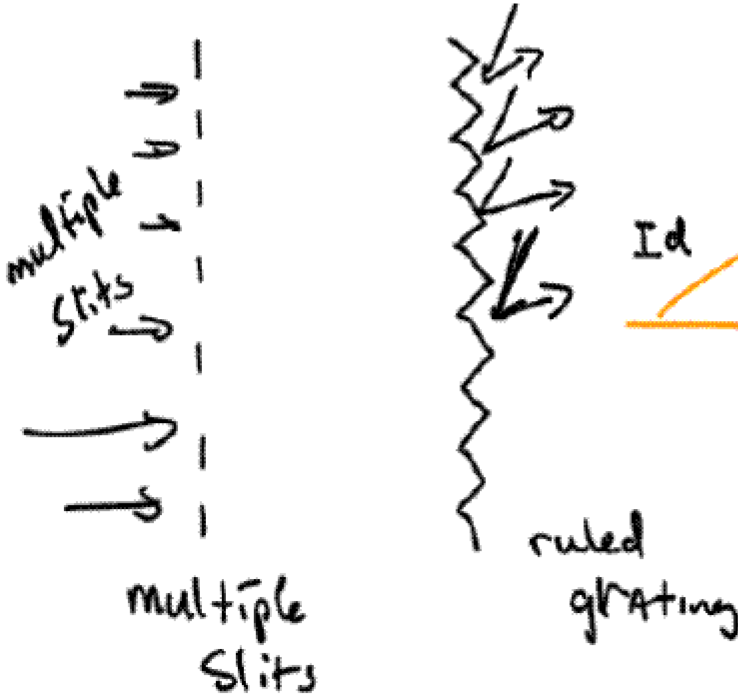
Double Slit

in reality

Diffraction + interference

Cent Diff. Max. Width $\sim \frac{\lambda}{a} = \sin\theta$

Diffraction Grating



Id

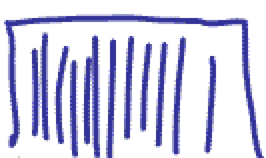
Intensity Maxima

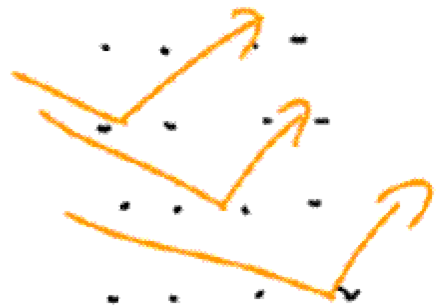
$$\boxed{d\sin\theta = m\lambda}$$

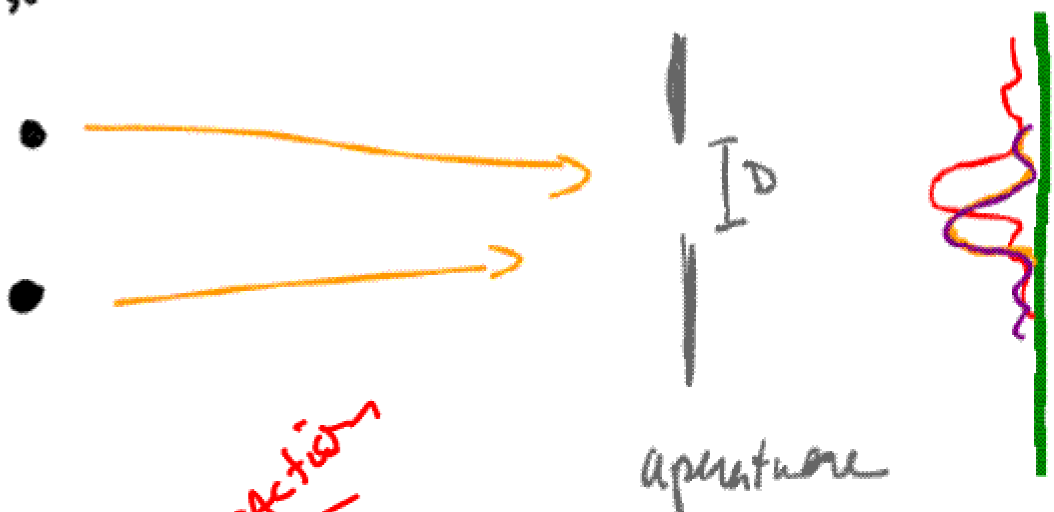
order

Spreads out the spectrum!

Used for most diagnostic spectroscopy

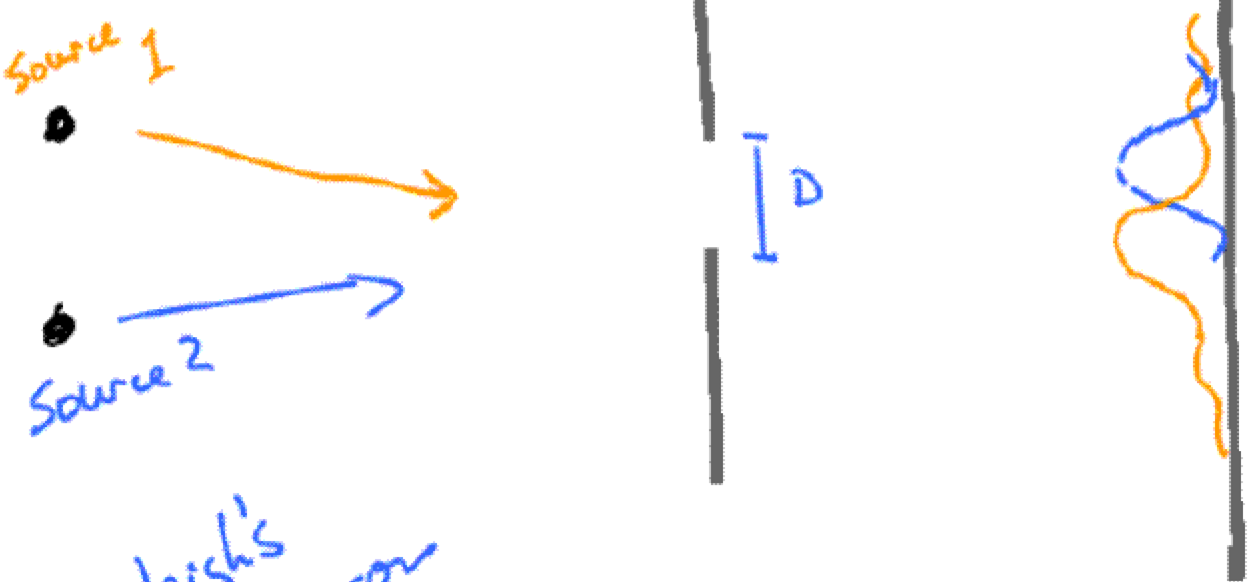






Resolving detail - limited by Diffraction

Central Max of one source $\geq$ the dist to the 1st Min of the other source



Rayleigh's Criterion

Central max for Source 2 falls on 1st minimum for Source 2

Say this is the minimum resolvable separation

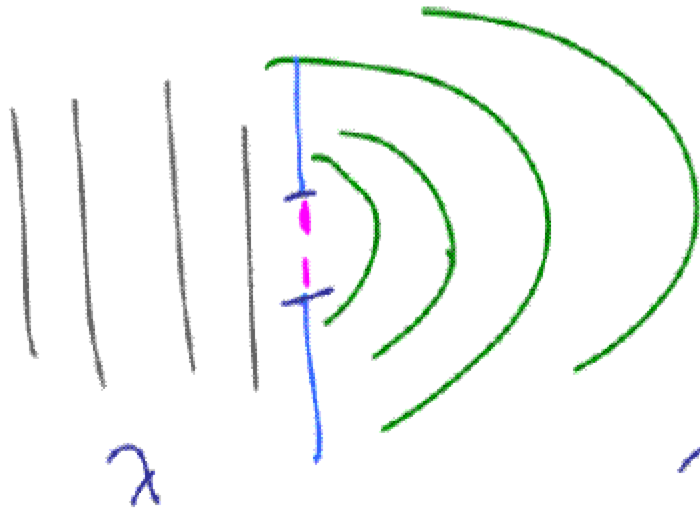
Thin slit

$\sin\theta = \frac{\lambda}{a}$ posn of 1st min $\longrightarrow$ Circular Aperture $\sin\theta = 1.22\frac{\lambda}{a}$ or $1.22\frac{\lambda}{D}$

small θ

$$\sin\theta \sim \boxed{\theta = 1.22\frac{\lambda}{D}}$$

Diffraction



Diffraction limits resolution
of Microscope/Telescopes