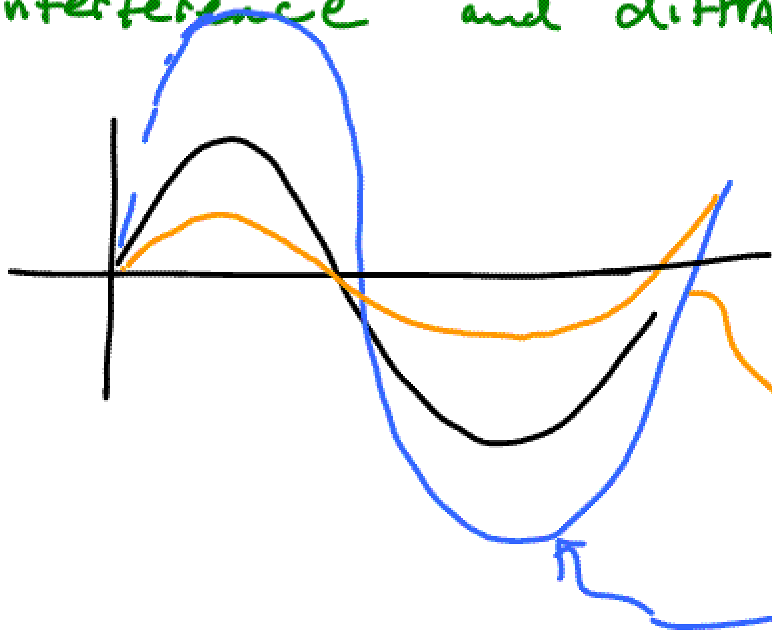
Physics 142 – December 6, 2005

Physical Optics

Interference and diffraction

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

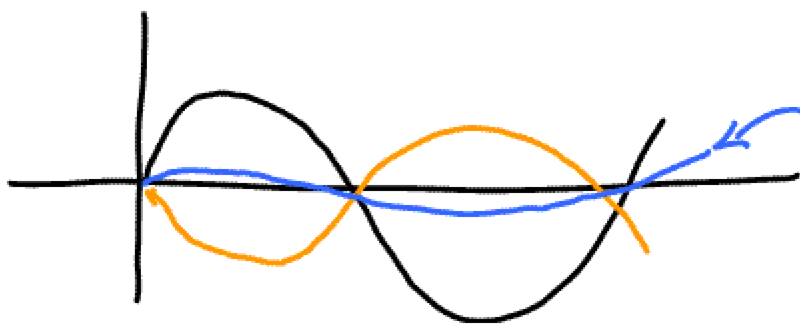
$$\vec{E}_2 = \vec{E}_{02} \sin(\omega t - kz + \delta)$$



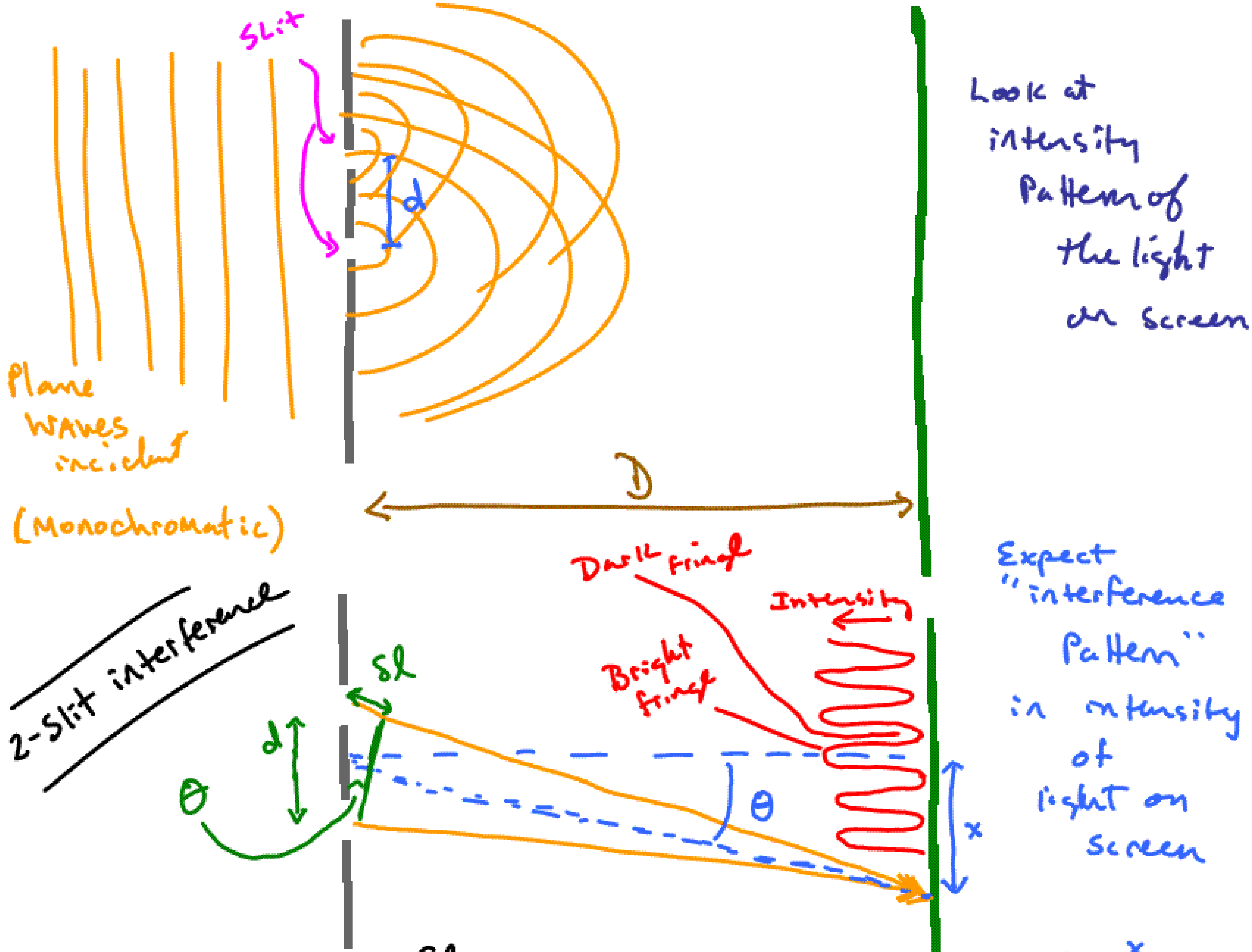
$\delta = 0$ in phase

= constructive interference

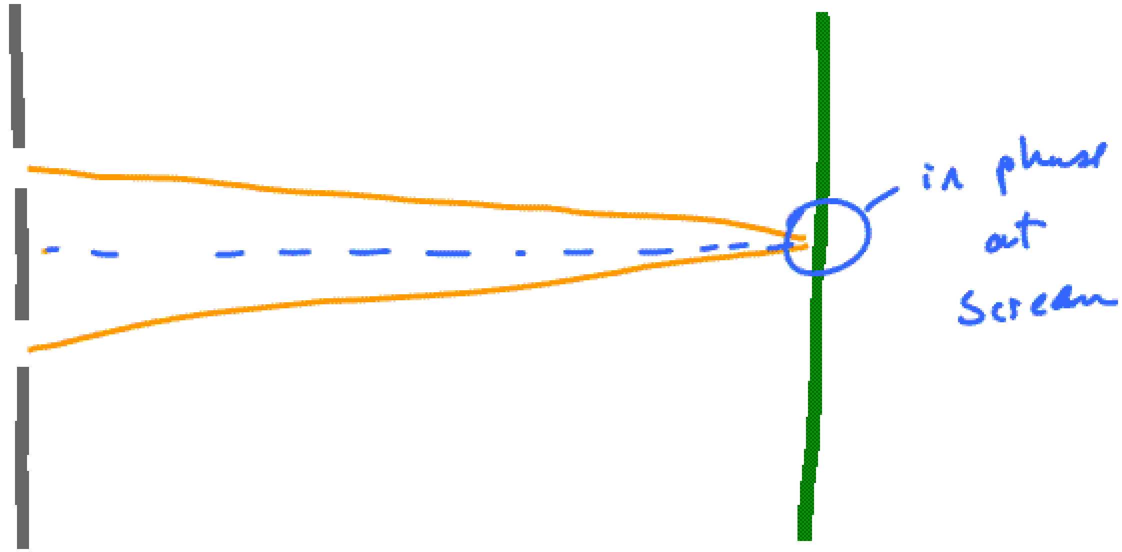
if $\delta = \pi$



Destructive interference



$$\frac{\delta l}{d} = \sin\theta \qquad \delta l = d\sin\theta \qquad \tan\theta = \frac{x}{d}$$



Constructive Interference

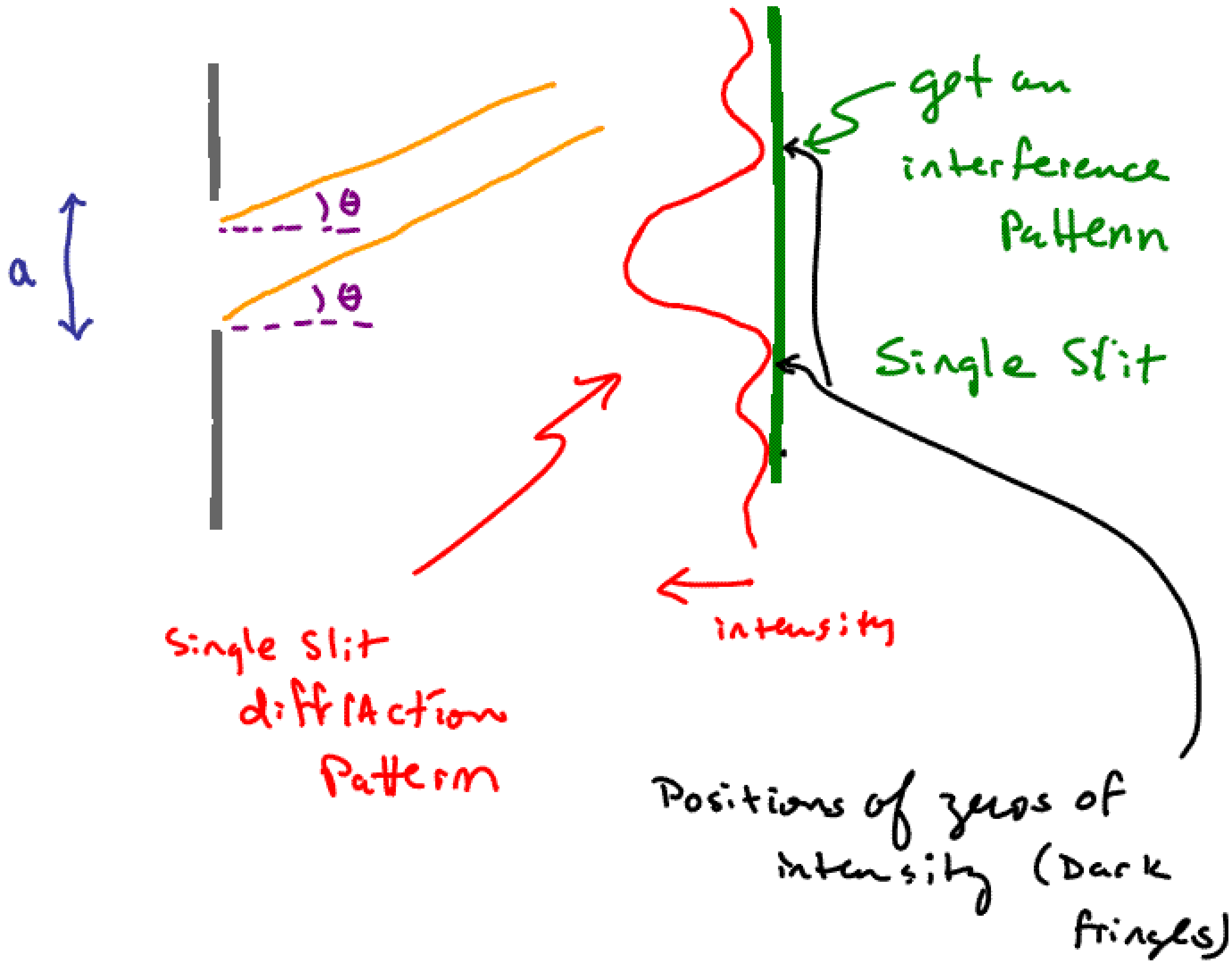
$$\delta l = m\lambda \qquad m = 0, 1, 2 \cdots$$

bright fringes on screen

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

destructive Interference

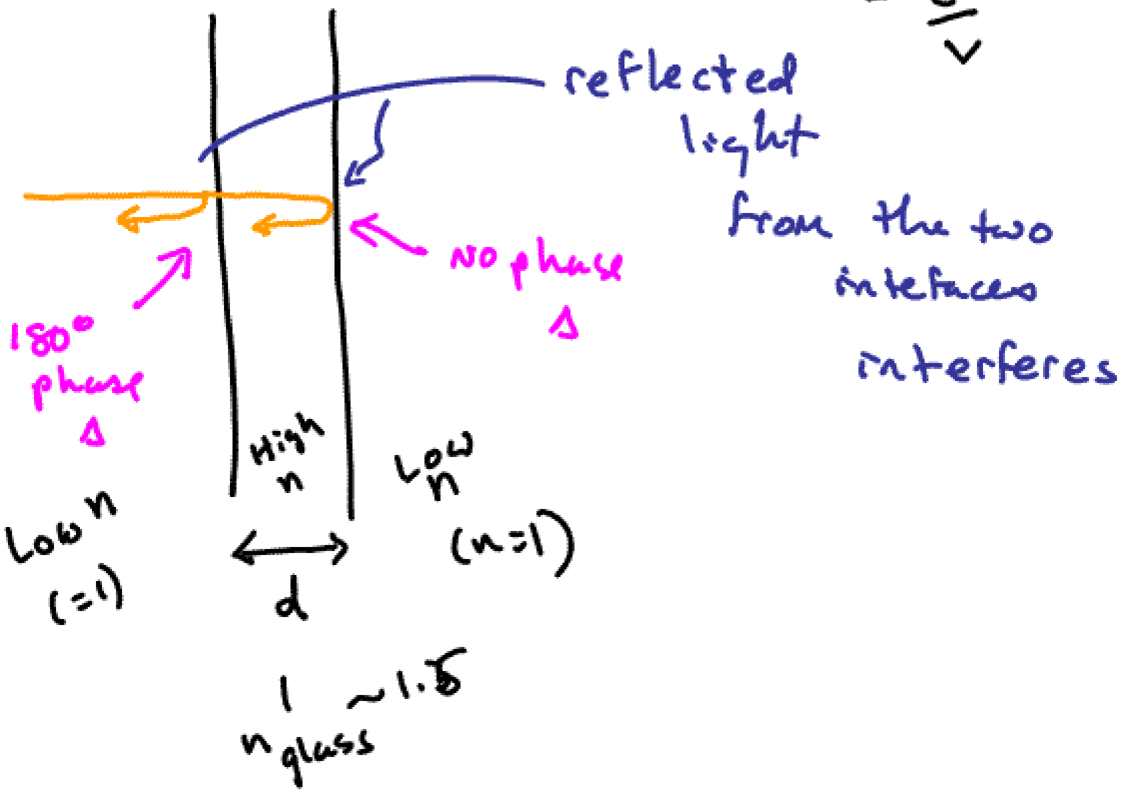
$$d \sin\theta = \left(m + \tfrac{1}{2}\right)\lambda \qquad m = 0, 1, 2 \ldots$$



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

Thin film interference

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



High n to low n ⇒ no phase change upon reflection

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

$$2d = m\lambda_n$$

λ in the material $\lambda_n = \lambda / n$

$m = 1, 2, 3 \ldots$

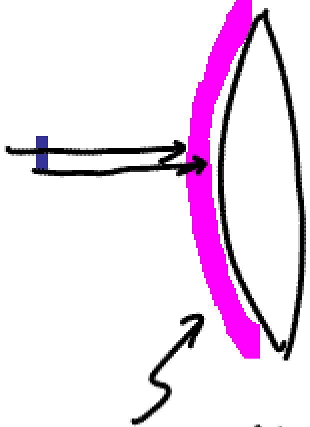
$2d$: extra distance traveled by wave penetrating glass

$=$ condition for destructive interference

(recall 180° phase Δ for one ray)

Constructive interference

$$2d = \left(m + \tfrac{1}{2}\right)\lambda_n = \left(m + \tfrac{1}{2}\right)\frac{\lambda}{n}$$



coating MgF_2

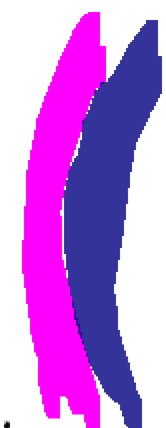
reduce reflection

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

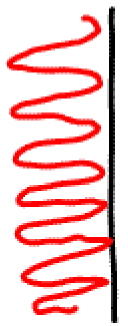
$$2d = \left(m + \tfrac{1}{2}\right)\lambda_n$$

$m = 0$

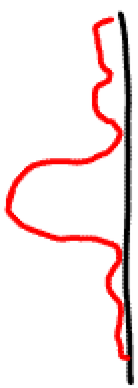
$$2d = \tfrac{1}{2}\lambda_n = \tfrac{1}{2}\frac{\lambda}{n}$$

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

Return to Diffraction



2-slit int pattern

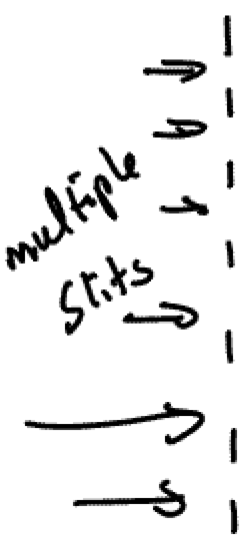


single slit diffraction

Diffraction + interference

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

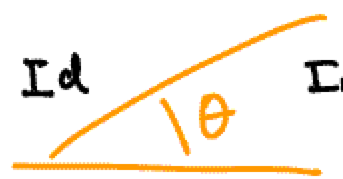
Double Slit



multiple Slits

ruled grating

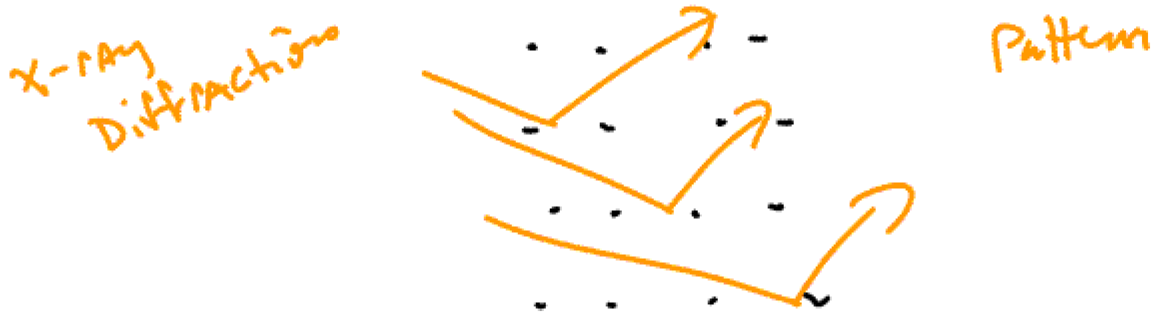
Id

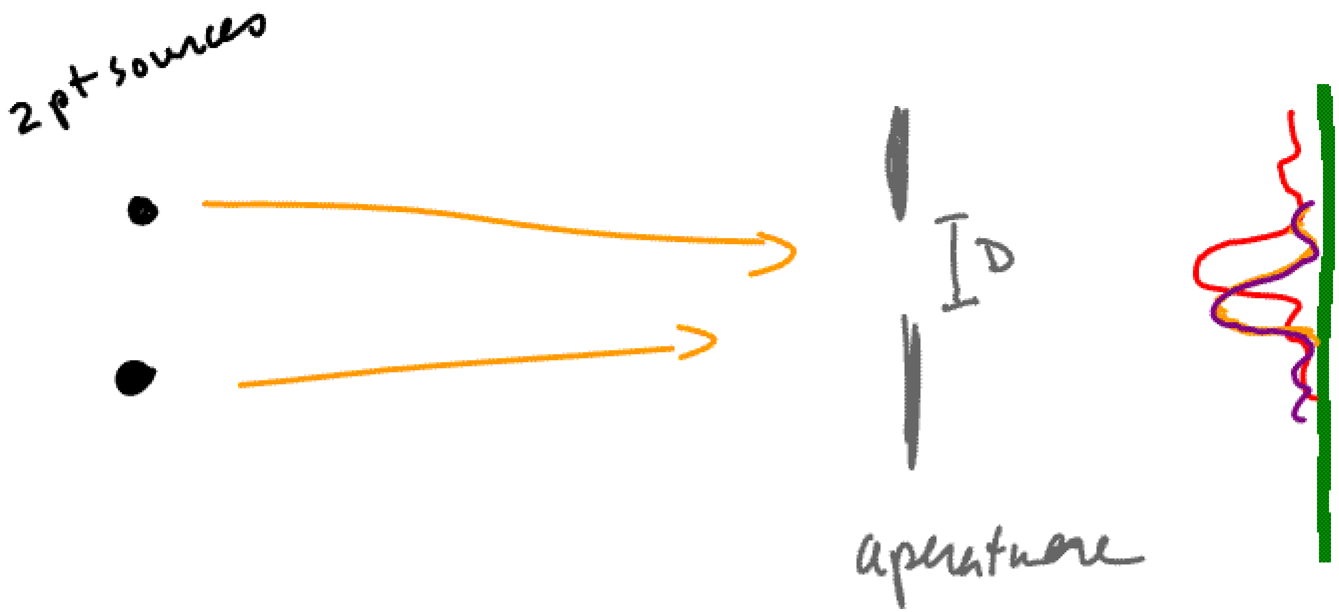


Intensity Maxima

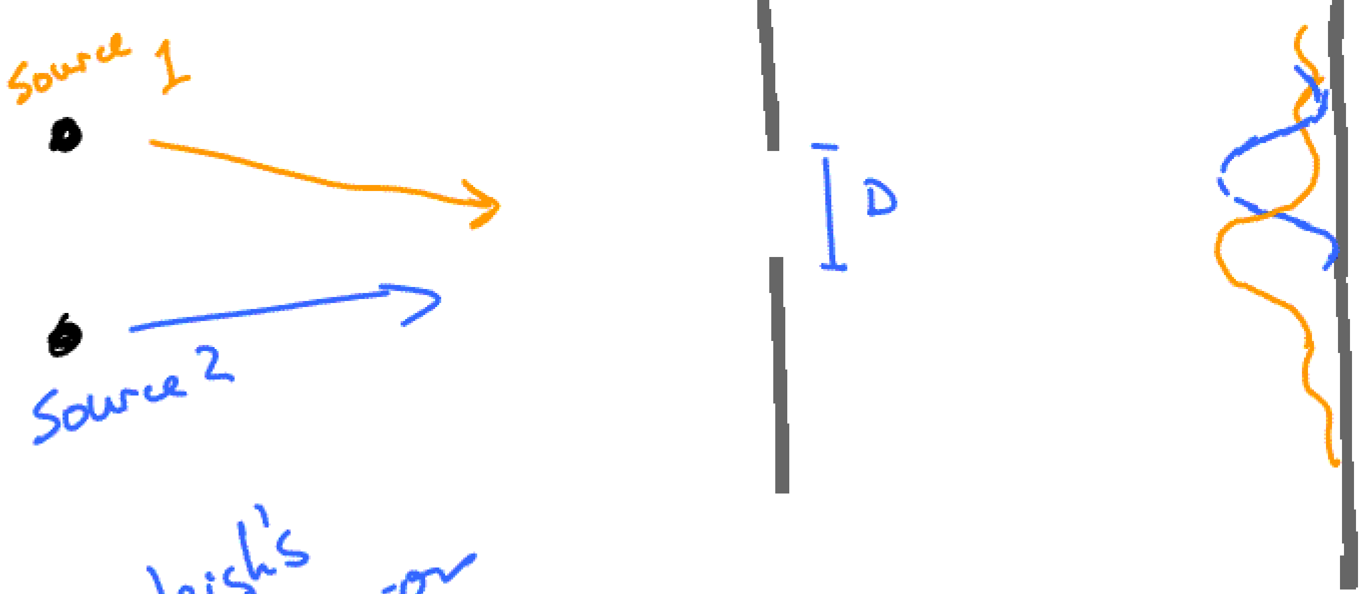
$d \sin\theta = m\lambda$

order





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

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