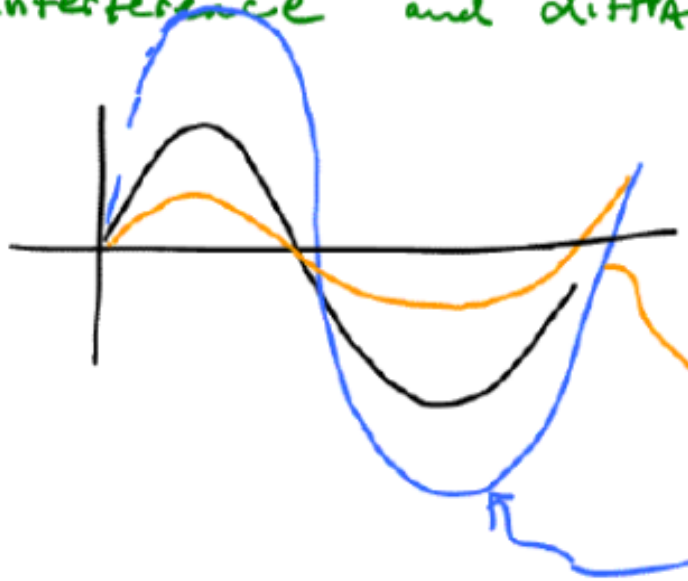
Physics 114 - April 14, 2015

Note Title 4/8/2010

- Exam 3 - Thursday - Hoyt
  During lecture slot
- Q+A - Today 5 PM
  B+L 106
- Using prepared slides today

Physical Optics

Interference and diffraction



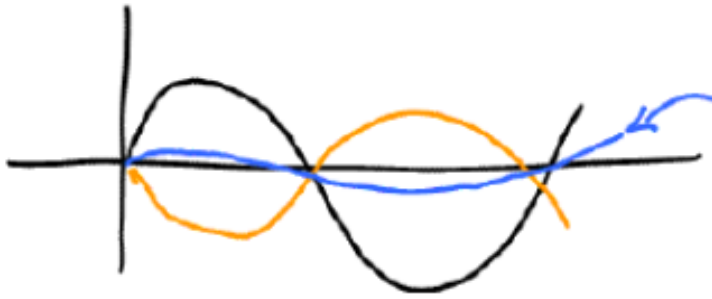
$\vec{E}_1 = \vec{E}_{01} \sin(\omega t - kz)$

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

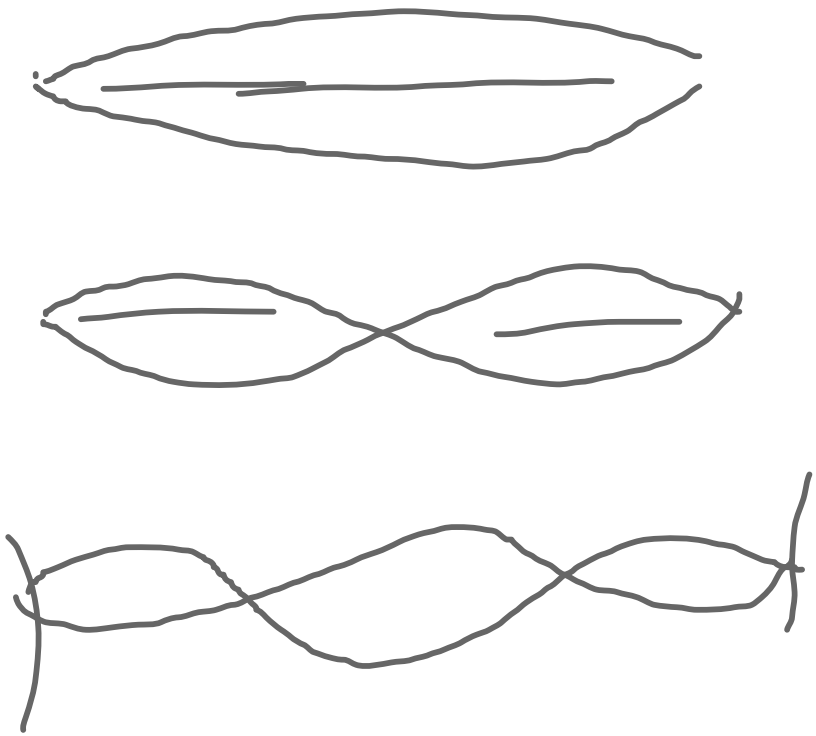
$\delta = 0$ in phase

constructive interference

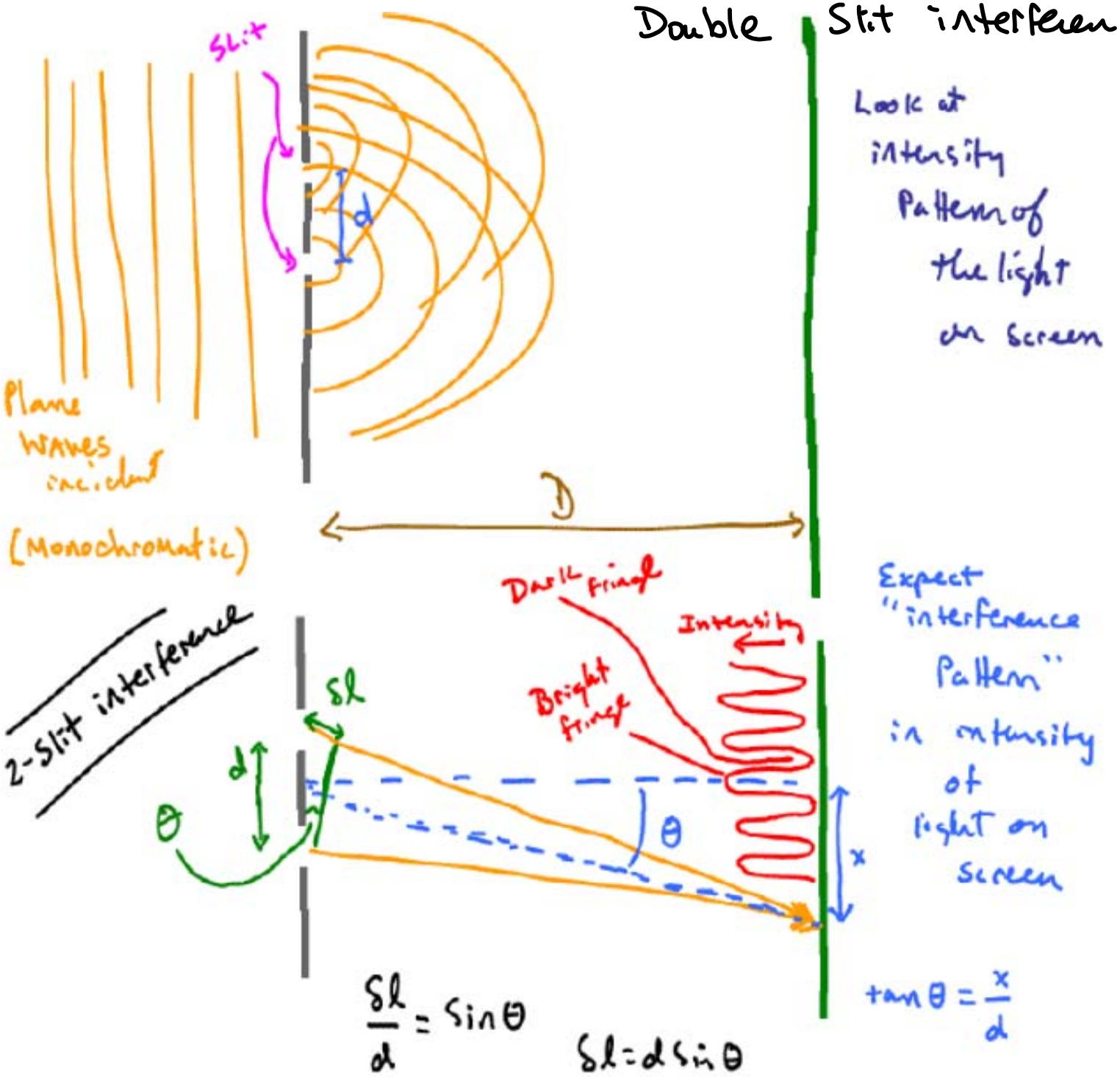
if $\delta = \pi$

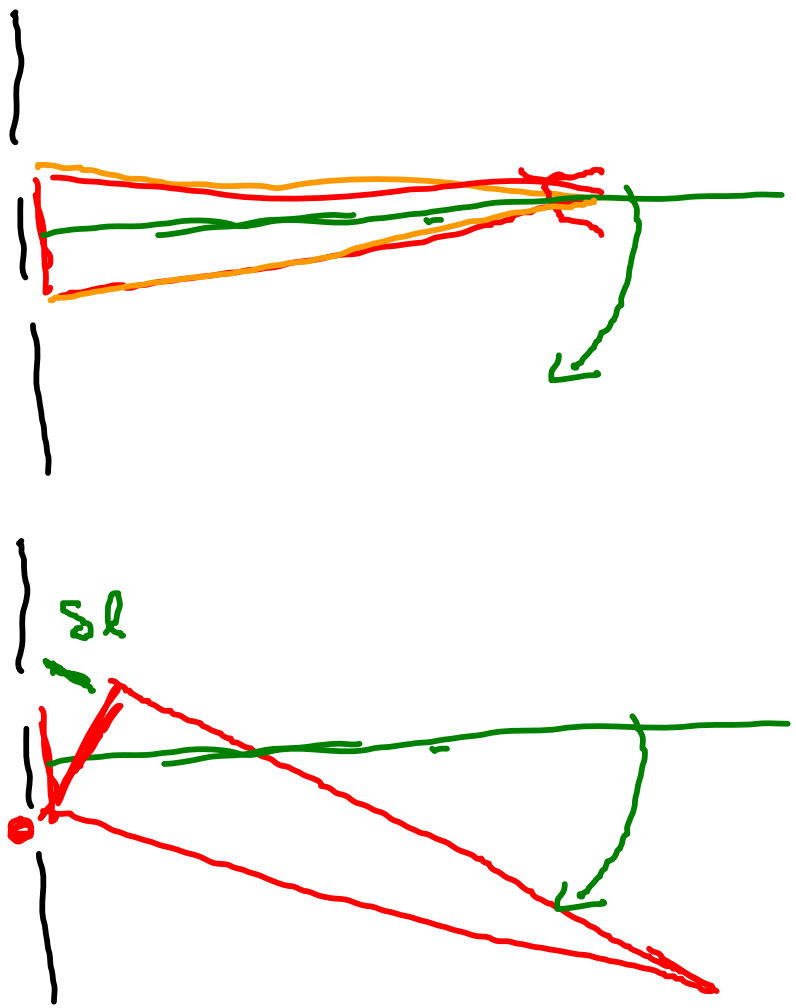


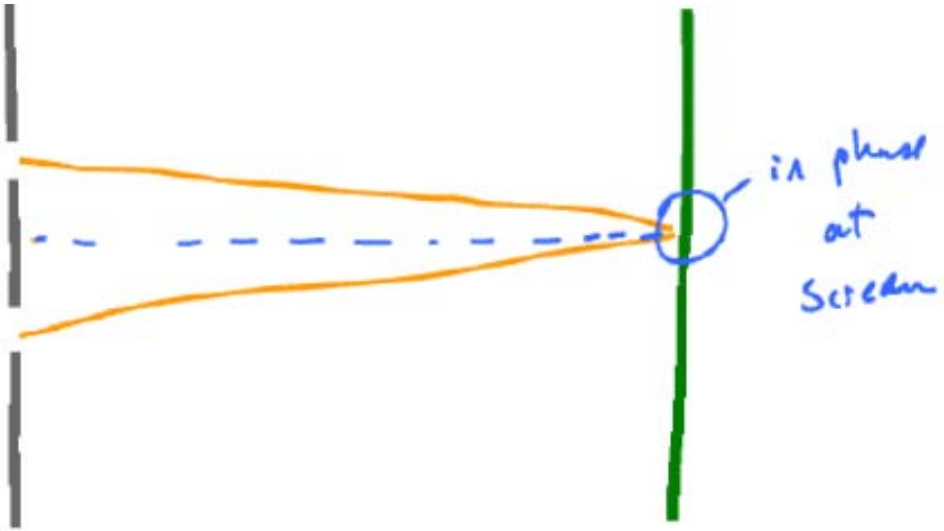
Destructive interference



Double Slit interference




sl



Constructive Interference

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

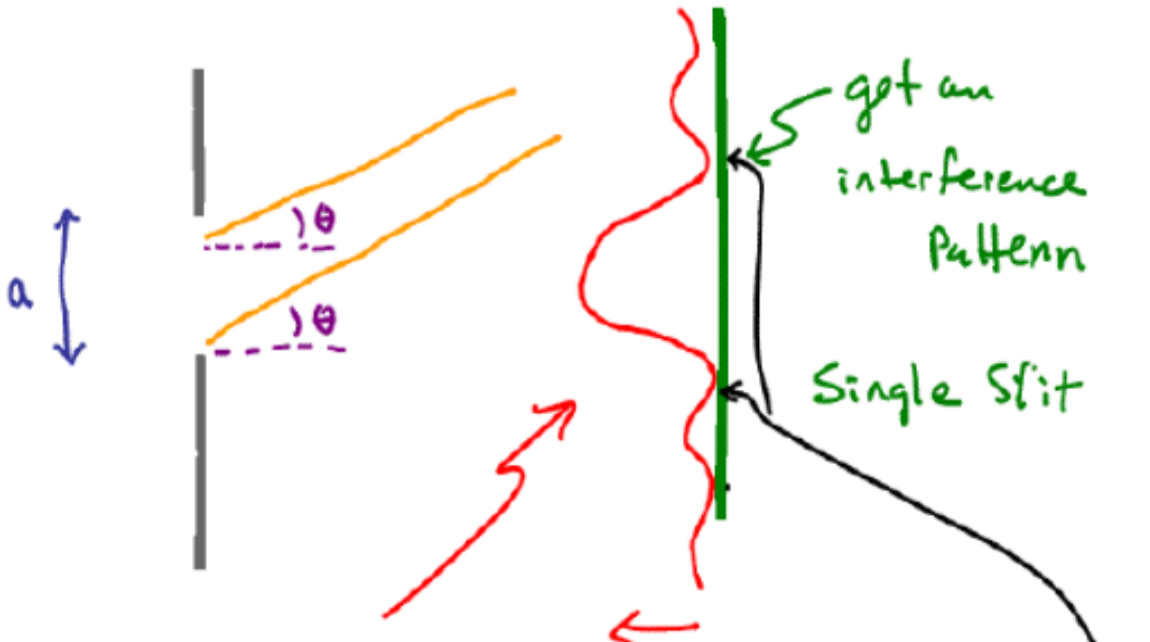
bright fringes on screen

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

destructive Interference

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

Single Slit Diffraction

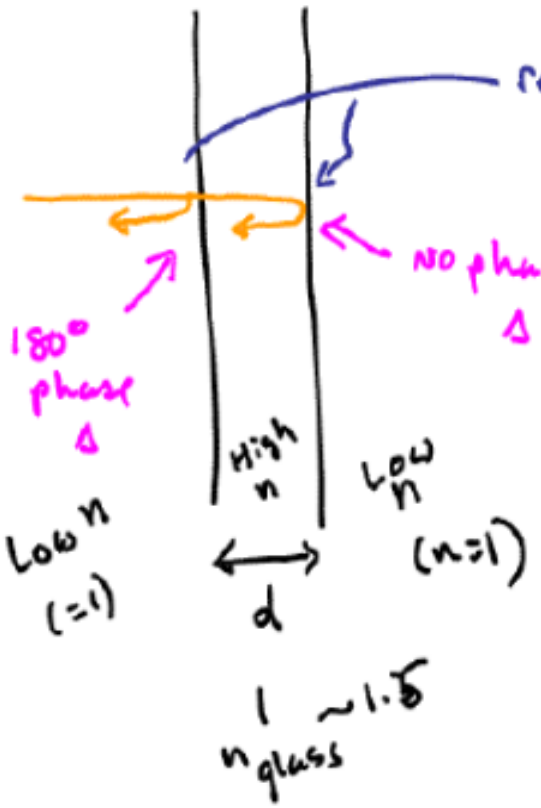


Positions of zeros of intensity (Dark fringes)

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

Thin film interference

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



from the two interfaces interferes

- Oil on water
- Anti-reflective coatings

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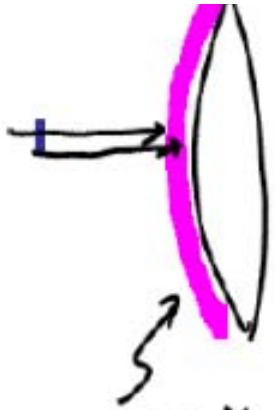
High n to low n ⇒ no phase change upon reflection

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



anti. reflective coating

coating MgF_2

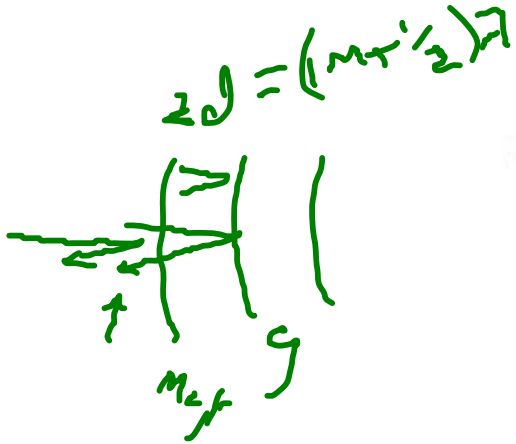
reduce reflection

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

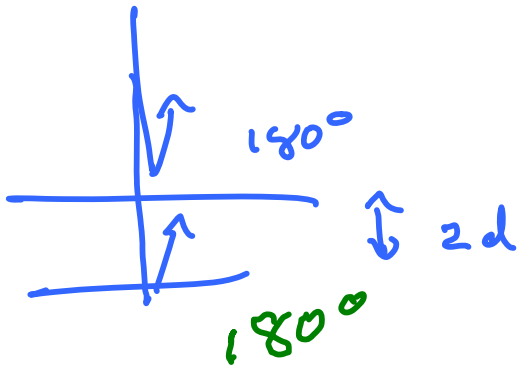
constructive Int

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

$m = 0$

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

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



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

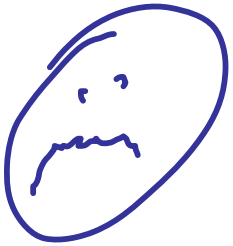
λ_n

λ/n

Must learn to think your
Way through These!

This
is
Fun!

Otherwise hopeless
+ hapless



Whoa with
Me!!

Return to Diffraction

2-slit int pattern

single slit diffraction

Double Slit

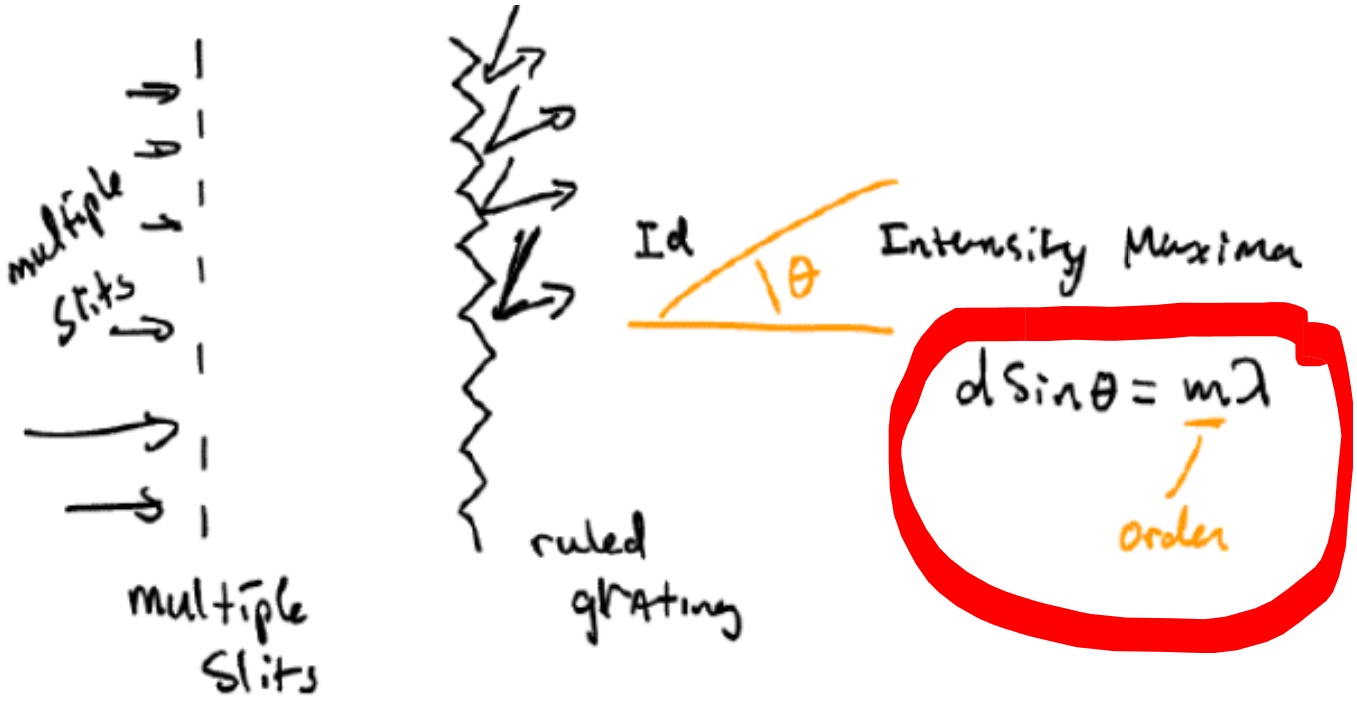
in reality

Diffraction + interference

Cent Diff. Max.

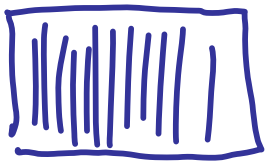
Width $\sim \frac{\lambda}{a} = \sin\theta$

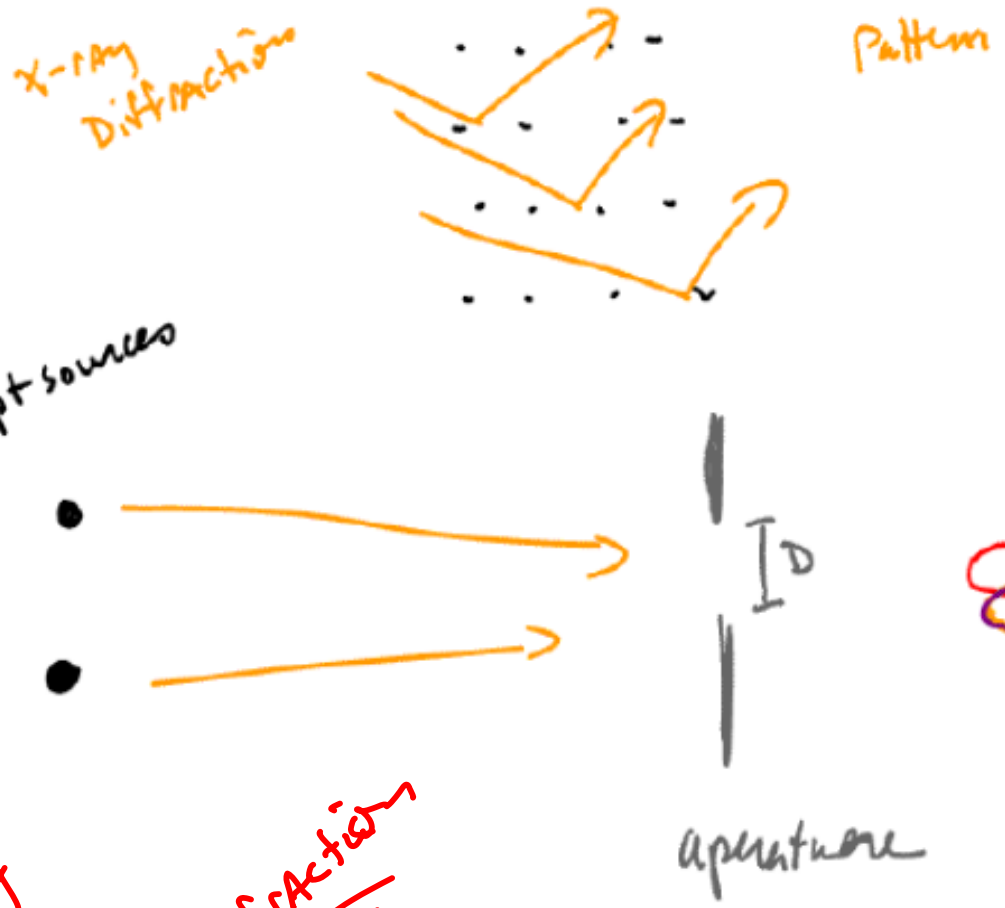
Diffraction Grating



Spreads out the spectrum!

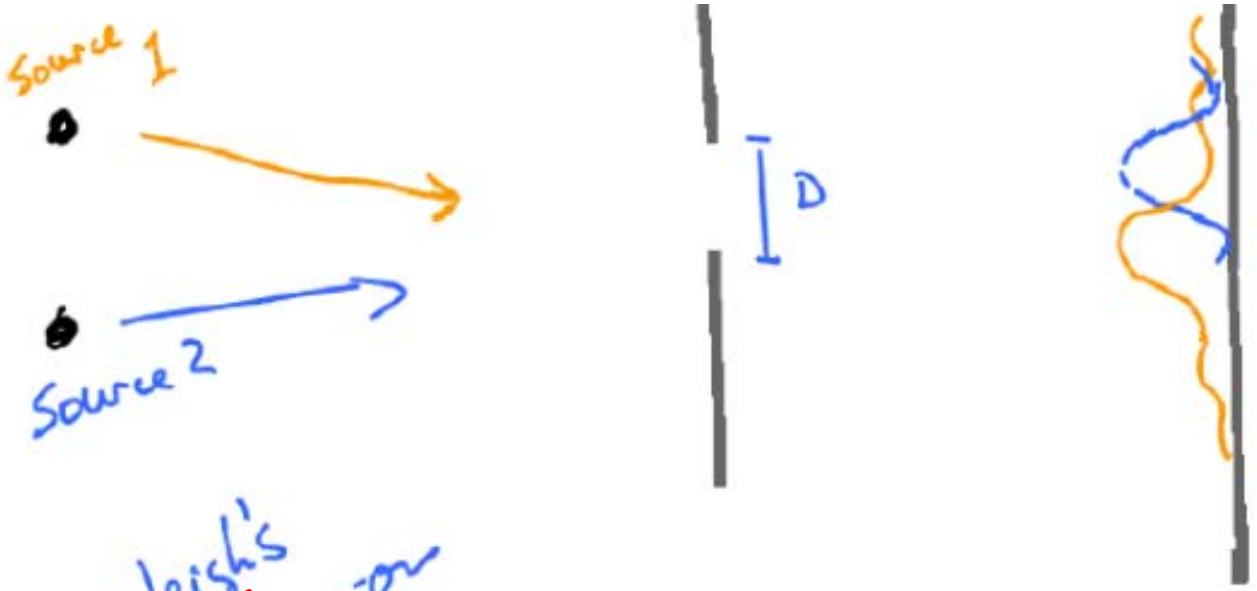
Used for most diagnostic spectroscopy





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

→ Circular Aperture

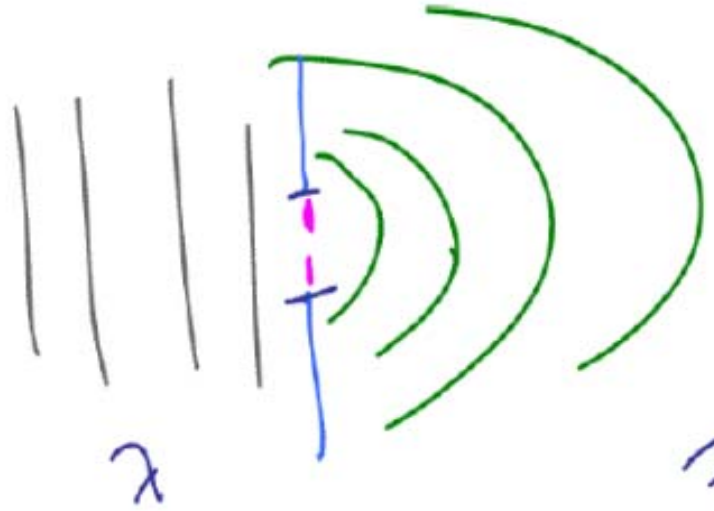
$\sin\theta = 1.22\frac{\lambda}{a}$

or

$1.22\frac{\lambda}{D}$

small θ

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

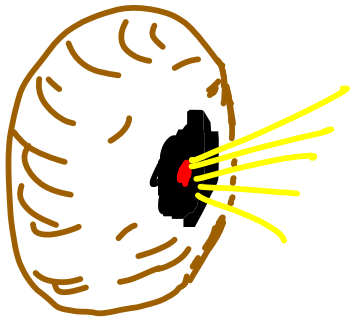


Diffraction

Diffraction limits resolution
of microscope / telescopes

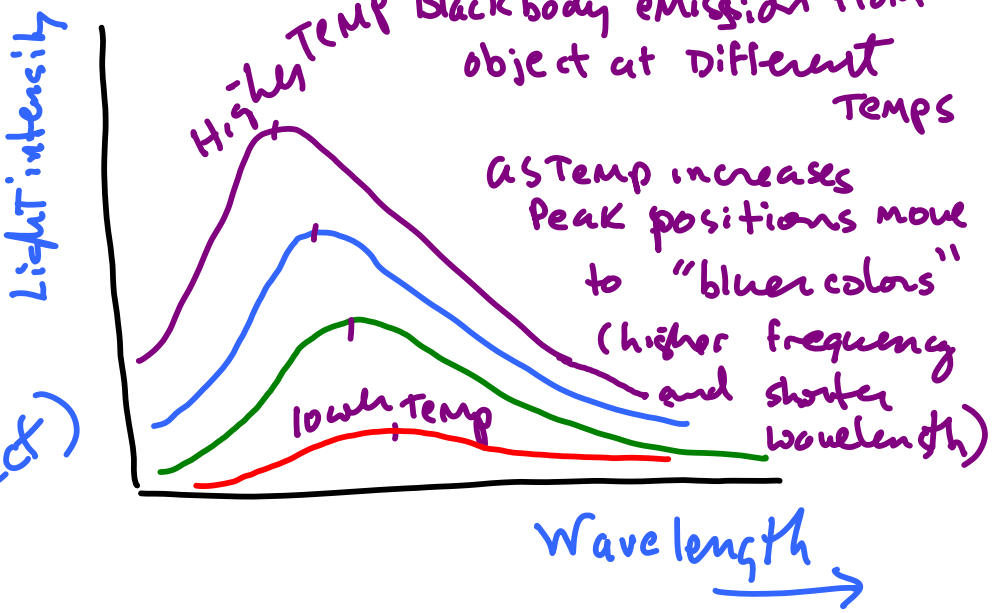
light is a wave

Blackbody Radiation



observer

"Blackbody" radiation (emitted by object)



Blackbody emission from object at Different Temps

as Temp increases Peak positions move to "bluer colors" (higher frequency and shorter wavelength)

Max Planck

(1858 - 1947)

German national

Awarded 1918 Nobel Prize in physics for analysis of blackbody radiation which contributed to rise of quantum Mechanics

http://www-history.mcs.st-andrews.ac.uk/Mathematicians/Planck.html