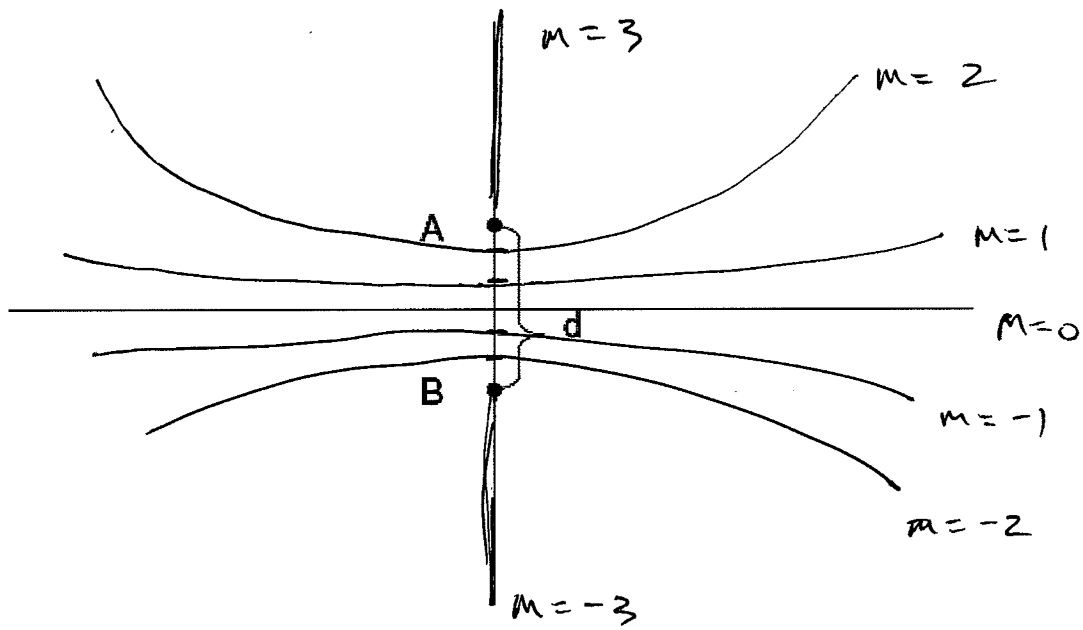
1.) (15 pts) Two point sources A and B emit perfect spherical waves. The sources are in phase.

a.) (10 pts) Sketch the resulting fringe pattern over the plane of the paper if the distance d is three wavelengths. Label fringe order numbers.

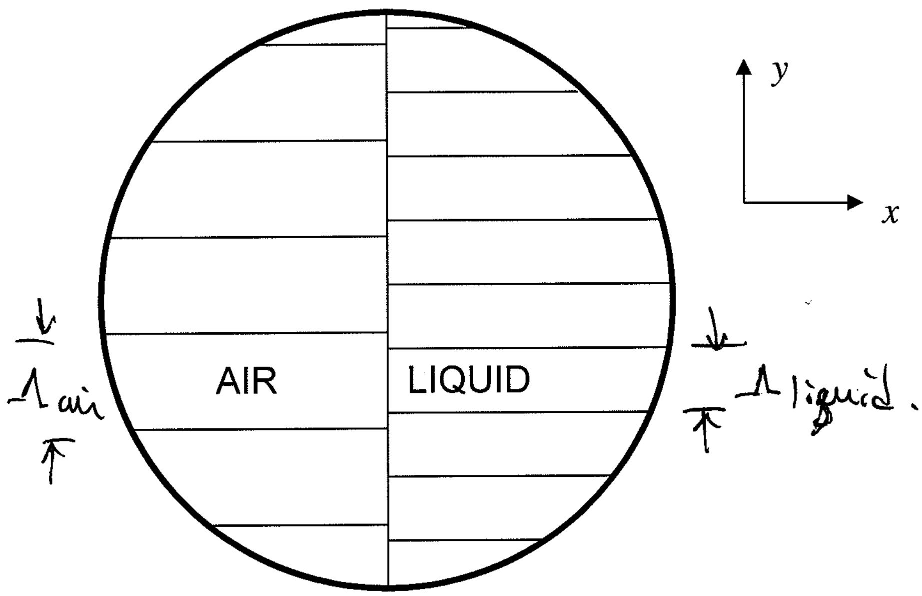
b.) (5 pts) How would your diagram change if source A is out of phase with source B by 180^0?

a)



b) Bright fringes become dark and dark fringes become bright.

2.) (15 pts) Two perfect optical flats are used to produce a Fizeau film, which has a simple linear wedge in the *y* direction. Straight-line, equally spaced fringes are observed with air in the wedge when viewed with a quasimonochromatic source. An unknown liquid is inserted into the right half of the Fizeau plate, as shown below.



a.) (10 pts) What is the real part of the liquid's refractive index if the fringe spacing observed in the air is 1.6 times the fringe spacing observed in the liquid? Justify your answer.

$t(y) = \alpha y$ $\qquad$ $OPD = 2nt(y)$ $\qquad$ Assume $\theta \approx 0$.

$= m\lambda$ for fringe.

$\Rightarrow \Lambda_{air} = \dfrac{\lambda}{2\alpha}$

$\Lambda_{liquid} = \dfrac{\lambda}{2n\alpha}$ $\qquad$ $\dfrac{\Lambda_{air}}{\Lambda_{liquid}} = \dfrac{\lambda/2\alpha}{\lambda/2n\alpha} = \boxed{n = 1.6}$

b.) (5 pts) Does the fringe shape have any dependence on the absorption of the liquid? NO.

3.) (~~15~~ 20 pts) Use Jones calculus to show that a half-wave plate converts right handed circularly polarized light into left handed circularly polarized light and the phase of the light can be changed by rotating the half-wave plate.

$$M_{HWP} = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$$

$$M^R_{HWP} = \begin{pmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{pmatrix}\begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}\begin{pmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{pmatrix}$$

$$= \begin{pmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{pmatrix}\begin{pmatrix} \cos\theta & \sin\theta \\ \sin\theta & -\cos\theta \end{pmatrix}$$

$$= \begin{pmatrix} \cos^2\theta - \sin^2\theta & \cos\theta\sin\theta + \sin\theta\cos\theta \\ \sin\theta\cos\theta + \cos\theta\sin\theta & \sin^2\theta - \cos^2\theta \end{pmatrix}$$

$$= \begin{pmatrix} \cos 2\theta & \sin 2\theta \\ \sin 2\theta & -\cos 2\theta \end{pmatrix}$$

$$M^R_{HWP}\begin{pmatrix} 1 \\ j \end{pmatrix} = \begin{pmatrix} \cos 2\theta + j\sin 2\theta \\ \sin 2\theta - j\cos 2\theta \end{pmatrix}$$

$$= \begin{pmatrix} \cos 2\theta + j\sin 2\theta \\ -j[\cos 2\theta + j\sin 2\theta] \end{pmatrix}$$

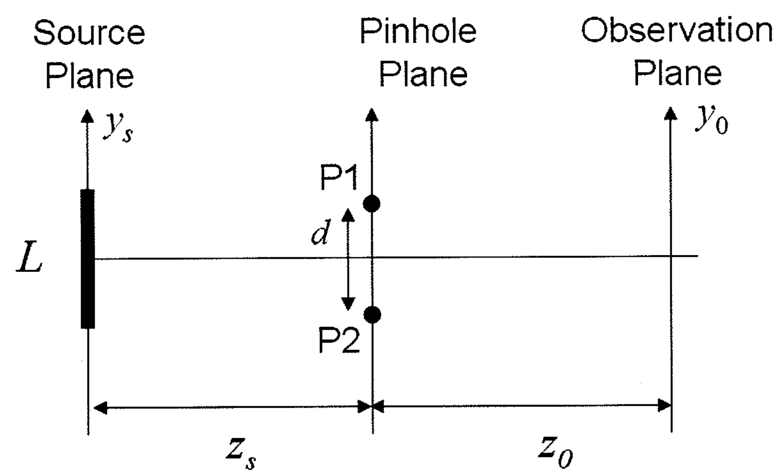
$$= [\cos 2\theta + j\sin 2\theta]\begin{pmatrix} 1 \\ -j \end{pmatrix}$$

$$= e^{j2\theta}\begin{pmatrix} 1 \\ -j \end{pmatrix}$$

4.) (20 pts) A quasi- monochromatic spatially incoherent source is used for a YDPI experiment. Let the radiant exitance of the source be given by the function

$$M_R(x_s, y_s) = I_0\left[1+\cos(2\pi y_s/T)\right] \delta(x_s)\,\mathrm{rect}\left(\frac{y_s}{L}\right)$$

where I_0 and T are constants. Let the width of the source in the y_s direction be L, where $L >> T$. Other parameters are z_s = 1m, T = 1mm and λ = 0.5μm. How does the fringe visibility depend upon z_0 and d? State any assumptions you make.



$z_s >> d$
$z_s >> \lambda$
$L << z_s$

C is a normalization constant.

$$M_R(x_s, y_s) = C\tfrac{1}{2}\left[1+\cos(2\pi y_s/T)\right]\delta(x_s)\,\mathrm{rect}\left(\frac{y_s}{L}\right)$$

$$\mu_{12} = \left[\frac{1}{2}\delta\left(\frac{\theta_A}{\lambda}\right) + \frac{1}{4}\delta\left(\frac{\theta_A}{\lambda}-\frac{1}{T}\right) + \frac{1}{4}\delta\left(\frac{\theta_A}{\lambda}+\frac{1}{T}\right)\right] * L\,\mathrm{sinc}\left(L\frac{\theta_A}{\lambda}\right)$$

This is very ~~wide~~ narrow compared to $1/T$.

Visibility only at

$$\frac{d}{z_s\lambda} - \frac{1}{T} = 0 \quad \text{or} \quad \boxed{d = \frac{z_s\lambda}{T}}.$$

Due to finite size of L, the visibility falls off quickly as a sinc fn around this point.

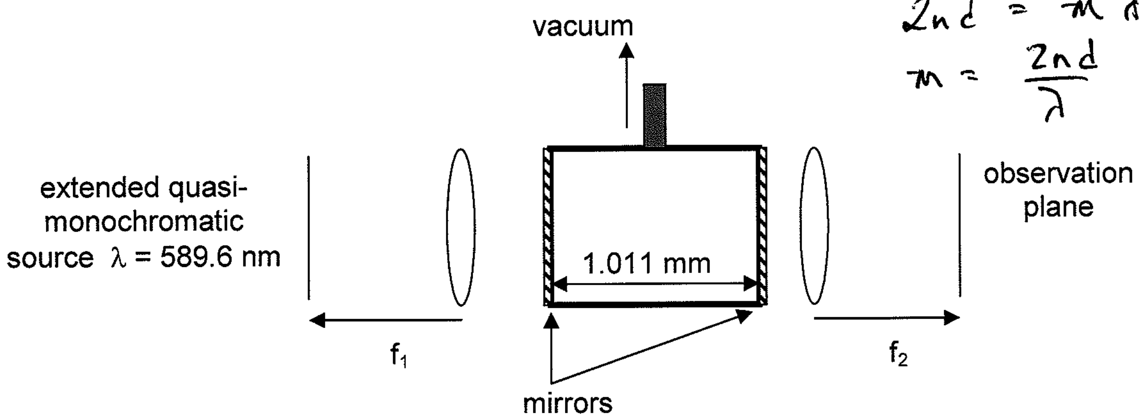
V is not a fn of z_0.

5.) (20pts) The Fabry Perot cavity below uses an extended quasi-monochromatic source. The cavity is composed of two highly reflective surfaces coated on a vacuum chamber such that the mirror separation is exactly 1.011 mm, regardless of the vacuum level.

At first, air is allowed in the chamber, and several fringes are observed in a concentric ring pattern. The central on-axis fringe is bright. As air is pumped out of the cavity, the graduate student watching the experiment notices that the first bright fringe beyond the center collapses and becomes the on-axis central fringe when vacuum is complete.

$2nd = m\lambda$

$m = \frac{2nd}{\lambda}$



a.) (10 pts) Is the vacuum a higher or lower index of refraction than the air? (Justify your answer.)

Fringe collapse ⇒ max. OPD has decreased. Since OPD = 2$\underline{n}$d, n of vacuum is lower than n of air.

b.) (10 pts.) What is the difference in the index of refraction between the air and the vacuum?

$$m = \frac{2n_{air}d}{\lambda} \qquad m-1 = \frac{2d}{\lambda}$$

$$m-(m-1) = 1 = \frac{2d}{\lambda}(n_{air}-1)$$

$$\therefore n_{air} = 1+\frac{\lambda}{2d} = 1+\frac{0.5896\times10^{-6}}{2\cdot 1.011\times10^{-3}}$$

$$\boxed{= 1.000296}$$

6.) (~~15~~ 10 pts) Describe ~~the~~ two similarities and two distinct differences between the Michelson interferometer and the Fizeau interferometer.

similarities:

1) Both effectively thin wedge with $OPD = 2nd\cos\theta$.
2) Both have fringe localization at mirrors if Michelson has titted mirrors w/ no separation.
3) Both can be used to see Haidinger's fringes

Differences:

1) Fizeau can't be adjusted for negative path.
2) Michelson doesn't use a fluid, so $n = 1$.
3.) Michelson Is more complicated