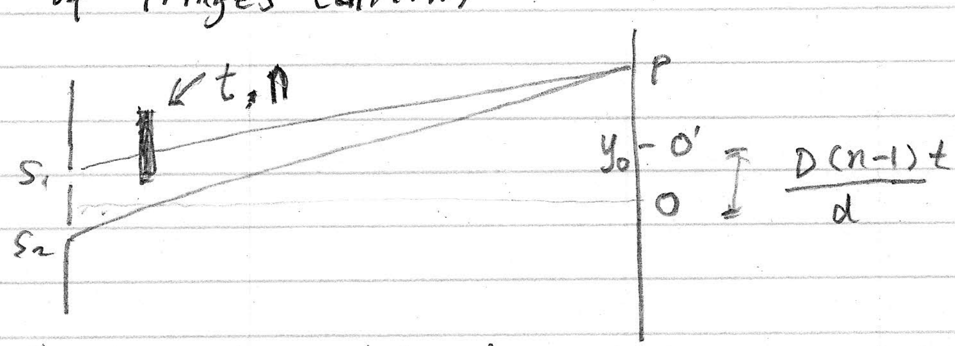
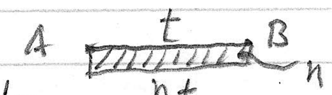
Lect. 14, March 23, 2010

Displacement of Fringes (Ch 14.10)



t: A thin transparent plate of width t is inserted.
The interference pattern is shifted by $\frac{D}{d}(n-1)t$.

Optical path $\tau = nt$.



~~true~~ Geometric path t, n: refractive index.
The time a light takes from A to B is

$$\text{Time} = \frac{\tau}{c} = \frac{nt}{c} = \frac{t}{c/n} = \frac{t}{v}$$

* Fermat's principle. from A to B, travel time is minimal.
alternatively, optical path is minimal.

phase shift due to travel a distance x

$$\delta = (kx) = \frac{2\pi}{\lambda}x = \frac{2\pi}{\lambda_0/n}x = \frac{2\pi}{\lambda_0}\underbrace{(nx)}_{\text{optical path}}$$

Optical path $S_1 \to P$: $S_1P - t + nt = S_1P + (n-1)t$
optical path $S_2 \to P$: S_2P

$$\Delta = S_1P - S_2P + (n-1)t = -y\frac{d}{D} + (n-1)t$$

The new fringe center at O'. $\Delta = 0 \Rightarrow y_0$

$$y_0 = \frac{D}{d}(n-1)t$$

This can be used to measure ~~make~~ the thickness of a thin sheet.

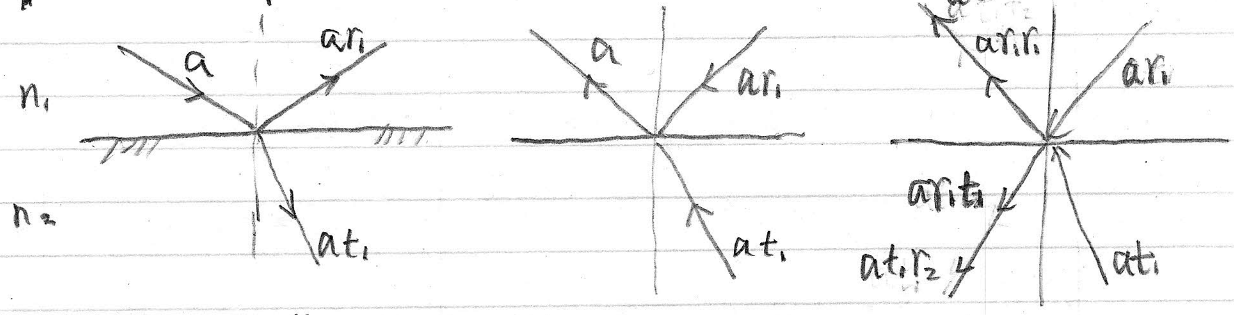
Exp: shift of fringe $y_0 = 0.2$ cm, $d = 0.1$ cm, $D = 50$ cm, $n = 1.58$

$$t = y_0\frac{d}{D(n-1)} = 6.9 \times 10^{-4}\ \text{cm}$$

phase change on Reflection (CH 14.11, CH 14.12)
Stokes's Relation

When light gets reflected by a denser medium, there is an abrupt phase change of π;
no such abrupt phase change occurs when reflection takes place at a rarer medium

Principle of optical reversibility:



r: reflection coefficient
t: transmission coefficient

First $ar_1t_1 + ar_2t_1 = 0$

$\Rightarrow r_2 = -r_1$ ------ (39)

"$-$" indicates phase change

$\vec{E}$: upon reflection on denser medium, $\vec{E}$ the same direction
$\vec{K}$: reverse the direction

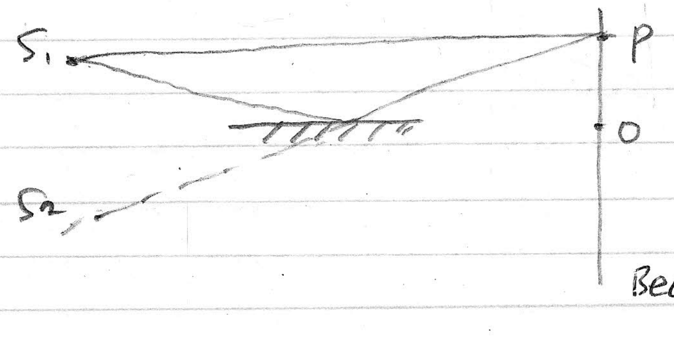
Second. $ar_1r_1 + at_1t_2 = a$

$\Rightarrow t_1t_2 = 1 - r_1^2$ ... (40)

(39) + (40) : Stokes' Relations

Lloyd's mirror arrangement (14.11)

$\Delta = \overline{S_1P} - \overline{S_2P}$



At O point, $\Delta = 0$,

$\Delta = n\lambda \Rightarrow$ minima

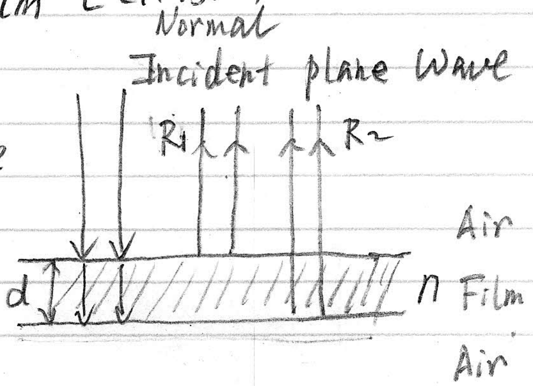
$\Delta = (n+\frac{1}{2})\lambda \Rightarrow$ maxima

Because of the π-phase change

Interference By Division of Amplitude : Two Beams (CH 15)

* Michelson Interferometer.
* Newton's Rings

Interference by a (plane parallel) film (CH 15.2)



R_1 : wave reflected by the upper surface
R_2 : wave reflected by the lower surface

Additional optical path of R_2 with respect to R_1

$\Delta = 2nd$

Further, R_1: sudden change of phase π at the interface of refrection
R_2: no sudden phase change

$\therefore$ $\Delta = m\lambda$, $m = 1, 2 \ldots$ destructive interference
the film appears to be dark

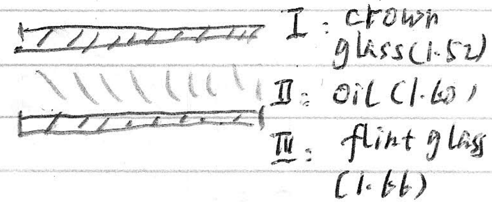
$\Delta = (m + \frac{1}{2}\lambda)$, $m = 1, 2 \ldots$ constructive interference
the film appears to be bright,

If the film is air between two glasses

$\Delta = m\lambda$. destructive interference

R_1 ; no sudden phase change
R_2 ; sudden phase change

If the film is oil between different glasses



e.g. $n_I = 1.52$ (Crown glass)
$n_{II} = 1.60$ (oil)
$n_{III} = 1.66$ (flint glass)

$\Delta = m\lambda \Longrightarrow$ constructive interference

Both R_1 and R_2 waves have sudden phase change of π