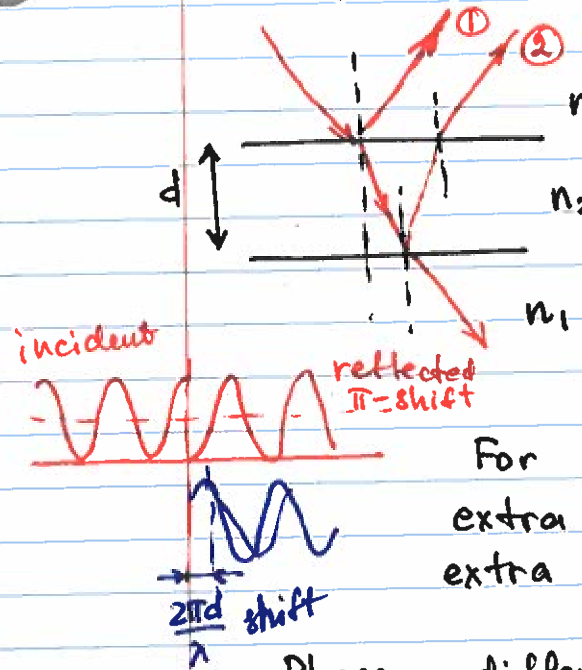
Thin film : soab bubbles



Beam ① → phase flips by $180° = \pi$ (since $n_1 < n_2$ @ reflection)

Beam ② → no phase flip (since $n_2 > n_1$ @ reflection) but has extra phase due to propagation in the film

For nearly - normal incidence

extra physical distance — $2 \times d = \Delta x$

extra optical phase — $\frac{2\pi n_2}{\lambda_0} \Delta x = \frac{4\pi \cdot d n_2}{\lambda_0}$

Phase difference b/w beams 1 and 2

$$\left(\frac{4\pi d n_2}{\lambda_0} - \pi\right) \begin{cases} = 2\pi m & \text{for constructive interference} \quad m = 0, 1, 2 \ldots \\ = 2\pi m + \pi & \text{for destructive interference} \end{cases}$$

"Bright" reflection $\frac{4\pi d n_2}{\lambda_0} - \pi = 2\pi m \Rightarrow \frac{4\pi d n_2}{\lambda_0} = \pi(2m+1)$

$$d_{max} = \frac{2m+1}{4} \cdot \lambda / n_2$$

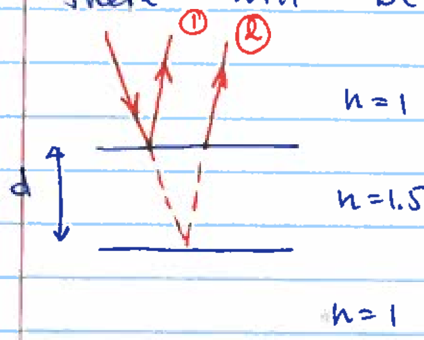
"Dark" reflection $\frac{4\pi d n}{\lambda_0} \cancel{-\pi} = 2\pi m \cancel{-\pi} \Rightarrow \frac{4\pi d n_2}{\lambda_0} = 2\pi m$

$$d_{min} = \frac{m}{2} \cdot \lambda_0 / n_2$$

Very thin film → min reflection for any color

First bright band occures for smaller wavelength — blue, then follows the spectrum to the red.

Example 1: If a bubble ($n = 1.5$) is illuminated with laser $\lambda_0 = 600nm$. At what thickness there will be no reflection?



Beam 1: π-phase is added upon reflection ($n > 1$)

Beam 2: no extra phase upon reflection, but extra distance traveled $2d$

extra phase: $\frac{2\pi}{(\lambda_0/n)} \cdot 2d = \frac{4\pi d n}{\lambda_0}$

Phase different b/w two beams after the film

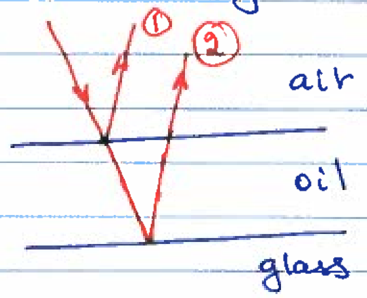
$$\frac{4\pi d n}{\lambda_0} - \pi = \pi + 2\pi m \qquad m = 0, 1, \ldots$$

$$\frac{4\pi d n}{\lambda_0} = 2\pi + 2\pi m$$

minimum thickness $m = 0$ $\quad d_{min} = \frac{\lambda_0}{2n} = \frac{600nm}{2 \cdot 1.5}$

$$\underline{d_{min} = 200nm}$$

Example 2: If we have an oil film on a plane of glass ($n_{oil} = 1.3$, $n_{glass} = 1.5$) illuminated with light with $\lambda_0 = 600nm$, at what thickness of oil film there is no glare (reflection)



$n_{air} < n_{oil} < n_{glass}$

Beam 1: extra π phase shift

Beam 2: extra π phase shift $+ 2d \cdot 2\pi/(\lambda_0/n_{oil})$

Phase difference b/w the beams

$$\frac{4\cancel{\pi} \cdot d \cdot n_{oil}}{\lambda_0} = \cancel{\pi}$$ destructive interference (smallest phase shift)

$$d = \frac{\lambda_0}{4 n_{oil}} = \frac{600\,nm}{4 \cdot 1.3} \approx 115\,nm$$