Today's Topics
- Review: Double Slit Experiment
- Thin Film Interference
- Change of Phase at Boundaries
- Exercise on Thin Film Interference
- Exercise on Non Reflective Coating
- Michelson Interferometer

Review: Interference of Light Waves

- Two light waves with same color and amplitude.
  \[ E_1 = E_0 \sin(\omega t - kx_1 + \phi_0) = E_0 \sin(\omega t + \phi_1) \]
  \[ E_2 = E_0 \sin(\omega t - kx_2 + \phi_{02}) = E_0 \sin(\omega t + \phi_2) \]
  \[ E = E_1 + E_2 = 2E_0 \cos(\Delta \phi/2) \sin(\omega t + \phi/2) \]

- Resulting amplitude: \( E_{\text{max}} = 2E_0 \cos(\Delta \phi/2) \)
  - Constructive interference: \( \Delta \phi = 0, 2\pi, 4\pi, \ldots \) \( E_{\text{max}} = 2E_0 \)
  - Destructive interference: \( \Delta \phi = \pi, 3\pi, 5\pi, \ldots \) \( E_{\text{max}} = 0 \)

→ It all depends on \( \Delta \phi \)!

Review: How to Calculate \( \Delta \phi \)?
Path Length And Path Length Difference

For two interfering waves coming through different paths the phase difference:

\[ \Delta \phi = \Delta \phi_{\text{at source}} + \Delta \phi_{\text{due to path}} + \Delta \phi_{\text{phase transition}} \]

\( \Delta \phi = 0 \) in many cases
\( = k(r_2 - r_1) = 2\pi\lambda(r_2 - r_1) \)

Recall phy201

Young's Famous Double-Slit Experiment
Thomas Young (1803)
Quantitatively

\[ \Delta \phi = 2\pi \lambda (r_2 - r_1) \]

path length difference

\[ r_2 - r_1 = \delta = ds \sin \theta \approx \theta \lambda \]

Double-Slit Experiment Explained

- **Constructive**: \( \Delta \phi = 0\pi, 2\pi, 4\pi, \ldots \) or \( 2m\pi, m=0,1,2\ldots \)
  \[
  \frac{2\pi d}{\lambda} \sin \theta = 2m \pi \quad \Rightarrow \quad d \sin \theta = m\lambda
  \]
  Bright spots

- **Destructive**: \( \Delta \phi = \pi, 3\pi, 5\pi, \ldots \) or \( (2m+1)\pi, m=0,1,2\ldots \)
  \[
  \frac{2\pi d}{\lambda} \sin \theta = 2(m+1) \pi \quad \Rightarrow \quad d \sin \theta = \left( m + \frac{1}{2} \right) \lambda
  \]
  Dark spots

Multi-Slit Interference

- # secondary maxima = \( N - 2 \)
- Higher \( N \) \( \rightarrow \) more suppression on secondary minima
  (Grating: \( N>1000 \), highly sensitive to \( \lambda \) good for measuring \( \lambda \).

Possible Phase Change of 180° For Reflected Light

- When a light traveling in medium 1 of \( n_1 \) is reaches at a boundary with medium 2 of \( n_2 \):
  - The reflected light has a 180°(\( \pi \)) phase shift if \( n_1 < n_2 \)
  - There is no phase change for reflected light if \( n_1 > n_2 \)
  - In any change, no phase shift for refracted light

\[
\begin{align*}
n_1 < n_2: & \quad 180^\circ(\pi) \text{ phase shift} \\
n_1 > n_2: & \quad 0^\circ \text{ phase shift}
\end{align*}
\]
Thin Film Interference

- Thin film splits light → split lights then interfere
- Lights 1,2 interfere
- Phase change $\pi$ for light 1
- $\Delta \phi_{12} = 2\pi l/n (2t) + \pi$
- Quiz: Constructive/destructive Conditions?
- Lights 3,4 also interfere
- $\Delta \phi_{34} = 2\pi l/n (2t)$

Exercise: Non Reflective Coating

- Determine the minimum thickness (t) of SiO coating so a light of 550nm is non-reflective at the surface.

Solution (see board):
- Non "reflective" → 1 and 2 cancel each other (destructive interference)
- $\Delta \phi_{12} = 2\pi l/n, 2t + 0^\circ = \pi$
- $t = \lambda/4 = \lambda/4n = 94.8$ nm.
- Note t is $\lambda$ dependent.

Newton's Rings

Demos

Testing glass for flatness

Colorful Interference Patterns
Demo: Michelson Interferometer

Exercise:
Work out $\Delta \Phi$ in this case
Discuss with your TAs
Also in the home work.