Lecture 27: learning objectives

You will be able to explain coherent and incoherent light.

You will be able to apply the conditions for constructive and destructive interference to Young’s double-slit experiment.

You will be able to explain interference in thin films.

You will be able to describe the physical origins of diffraction and analyse single-slit diffraction and diffraction gratings.
Properties of electromagnetic waves

Interference is hard to observe in light, because it has such a small wavelength. It helps if:

- The sources are **coherent**.
- The waves have identical wavelengths.

**Coherent waves:**
Waves which have the same wavelength and maintain a constant phase difference with respect to each other.

Here we are no longer applying the ray approximation!
Young’s double slit experiment

Path difference, $\delta$:
Difference in distance travelled by light waves passing through each slit.

$$\delta = r_2 - r_1 = d \sin \theta$$

Constructive interference = bright

$$\delta = d \sin \theta_{\text{bright}} = m\lambda$$

$$y_{\text{bright}} = m\frac{\lambda L}{d}$$

Destructive interference = dark

$$d \sin \theta_{\text{dark}} = \left(m + \frac{1}{2}\right) \lambda$$

$$y_{\text{dark}} = \left(m + \frac{1}{2}\right) \frac{\lambda L}{d}$$

The path difference between the two rays is $r_2 - r_1 = d \sin \theta$. 

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Thin film reflection

For single layer thin films additional phase change of reflected wave 1 but not 2.

**Constructive interference**

\[ 2nt = \left( m + \frac{1}{2} \right) \lambda \]

**Destructive interference**

\[ 2nt = m\lambda \]

Interference in light reflected from a thin film is due to a combination of rays 1 and 2 reflected from the upper and lower surfaces of the film.

180° phase change

No phase change

Film with index \( n \)

Surface A

Surface B

Air
Single-slit diffraction

\[
\sin \theta_{\text{dark}} = \frac{m \lambda}{a}
\]
Diffraction grating

An angle $\theta$ separates each principal maximum.

Incoming plane wave of light

First-order maximum ($m = 1$)

Central or zeroth-order maximum ($m = 0$)

First-order maximum ($m = -1$)

Constructive interference

$$d \sin \theta_{\text{bright}} = m \lambda$$

$\delta = d \sin \theta$