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TECHNOLOGY, RESEARCH, SOCIAL INNOVATION & PARTNERSHIPS

Engineering Physics (FYBTech)

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Interference

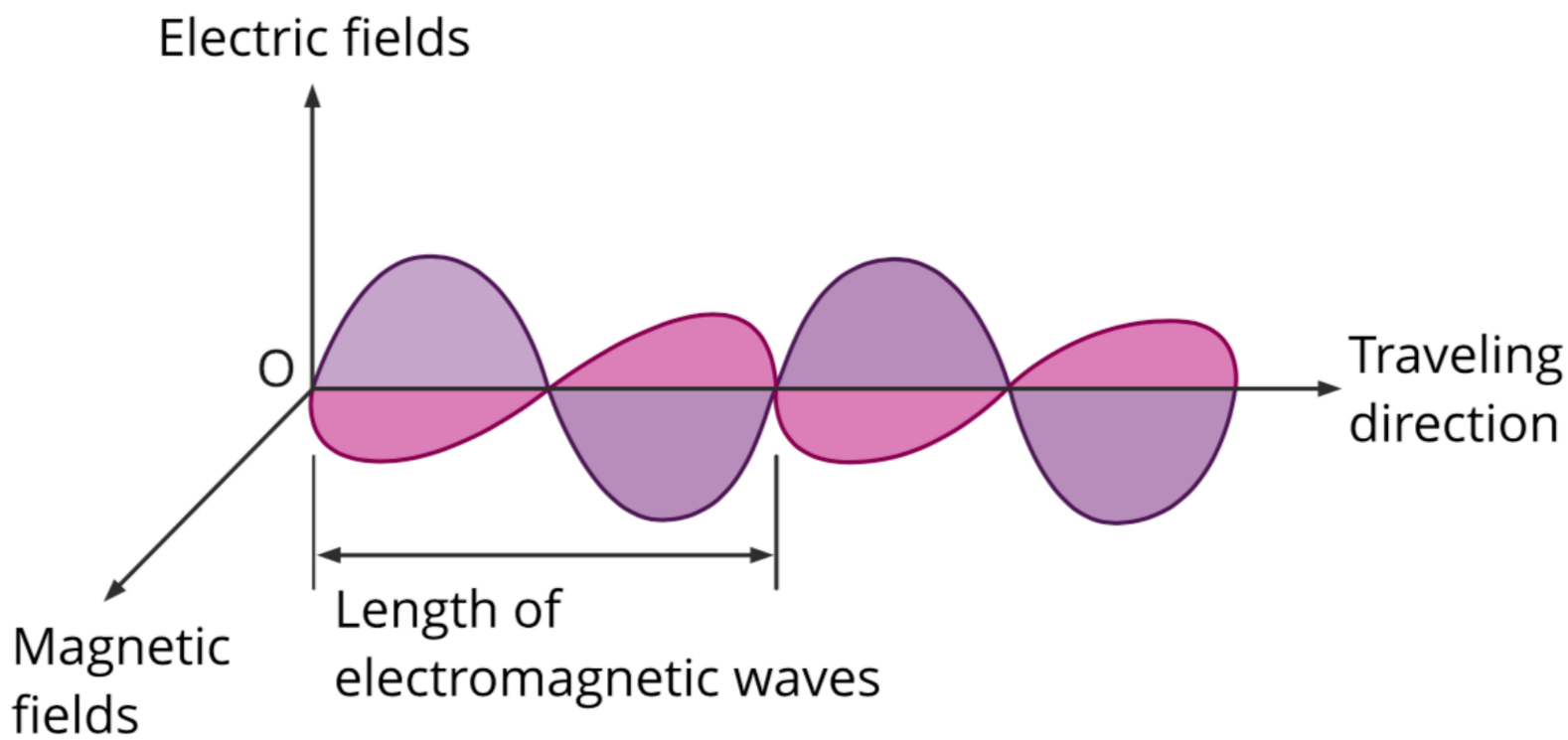
Content:

- Introduction to EM Waves
- Concept of Interference
- Thin Parallel film (Conditions maxima, minima, wedge shaped film, and fringe width (without derivations),
- Newton's rings Formation
  Applications of Newton's rings Antireflection (high transmission) coating
- Anti-transmission (high reflection coatings)

Electromagnetic Wave

An Electromagnetic waves are a propagating couple of an electric and magnetic field. They are hence known as 'electromagnetic' waves.

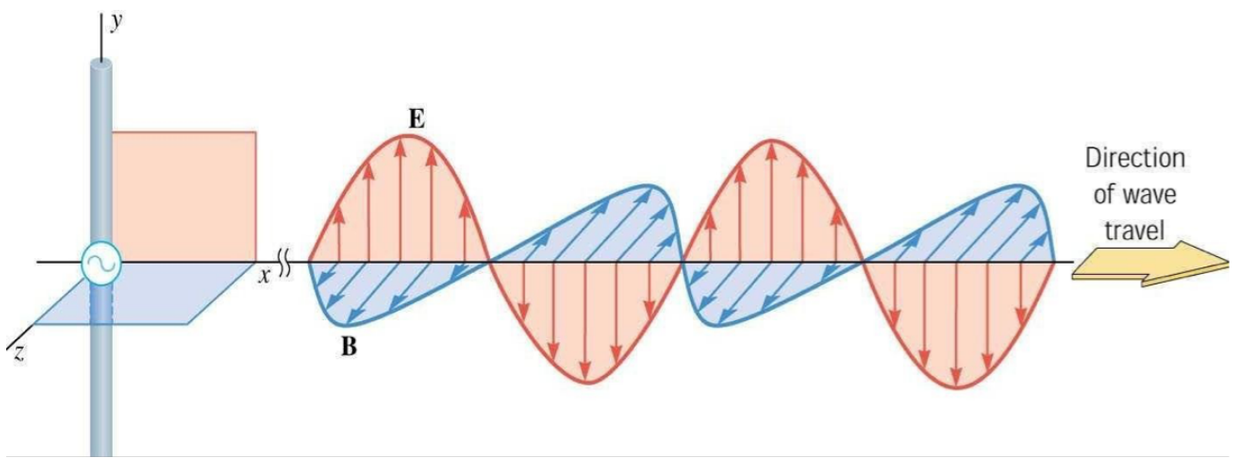
The electric and magnetic field vectors are at angle of 90 degree, and both are perpendicular to direction of propagation of wave.



Electromagnetic Wave

An electromagnetic wave can be created by accelerating charges. Moving charges back and forth will produce oscillating electric and magnetic fields, and this travel at the speed of light.

Properties of EM Wave

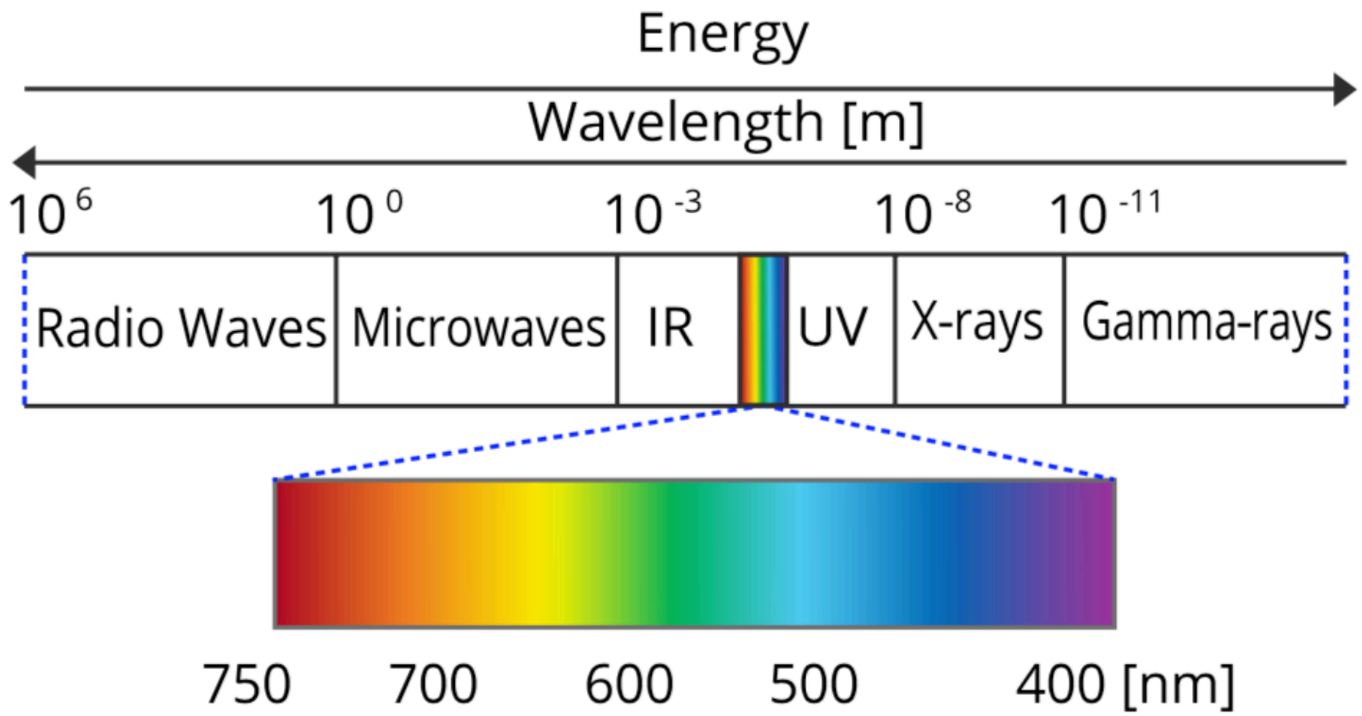


Speed of Light in a vacuum:
186,000 miles per second
300,000 kilometers per second
3 x 10^8 m/s

$$c = \frac{1}{\sqrt{\mu_0 \varepsilon_o}} = 3.0x10^8\, m/s$$

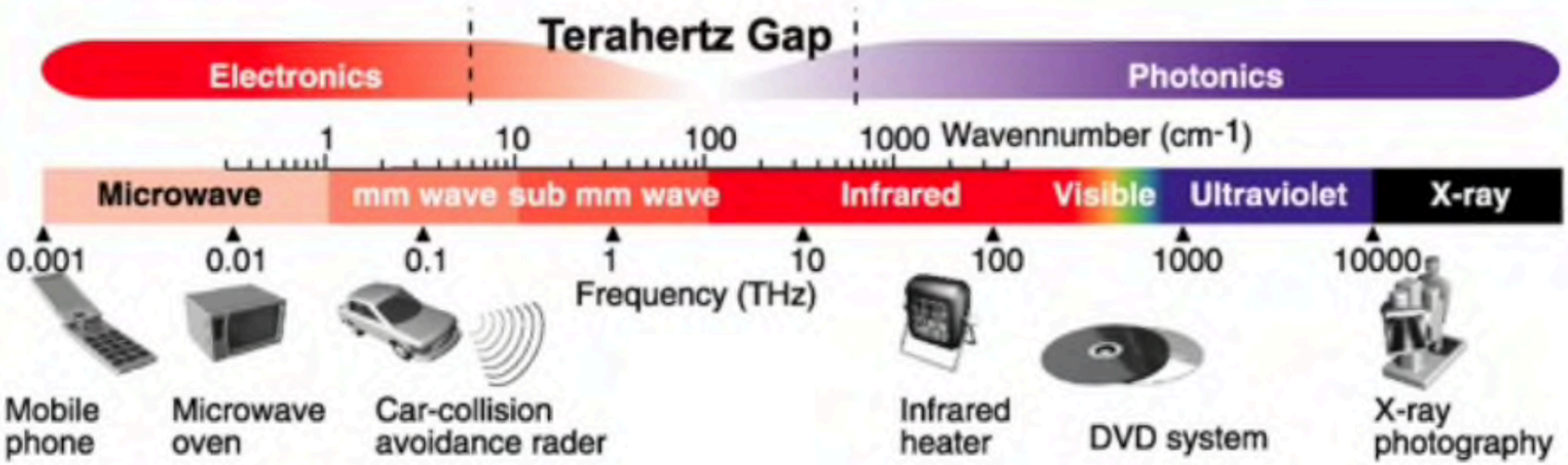
- They are transverse in nature.
- They consist of oscillating electric (E) and magnetic (B) field vectors at right angles to each other and at right angles to the direction of propagation of the wave.
- They can travel through a vacuum.
- They travel at the speed of light in vacuum, $c = 3 \times 10^8 m/s$.
- Electromagnetic wave follows the principle of superposition.
- Electric field part of the electromagnetic wave is the reason for the optical vision.
- They obey the wave equation $c = f\lambda$.
- Their frequencies remain unchanged but its wavelength changes when the wave travels from one medium to another.

Electromagnetic Spectrum



- The electromagnetic spectrum is the categorization of electromagnetic wave according to their wavelengths and frequencies.
- The behavior of an electromagnetic wave in a substance depends on its frequency or wavelength.
- Like visible light these waves can be transmitted, reflected, and absorbed but their properties are different from visible light.
- The Visible light is the type of electromagnetic waves to which our eyes responds.

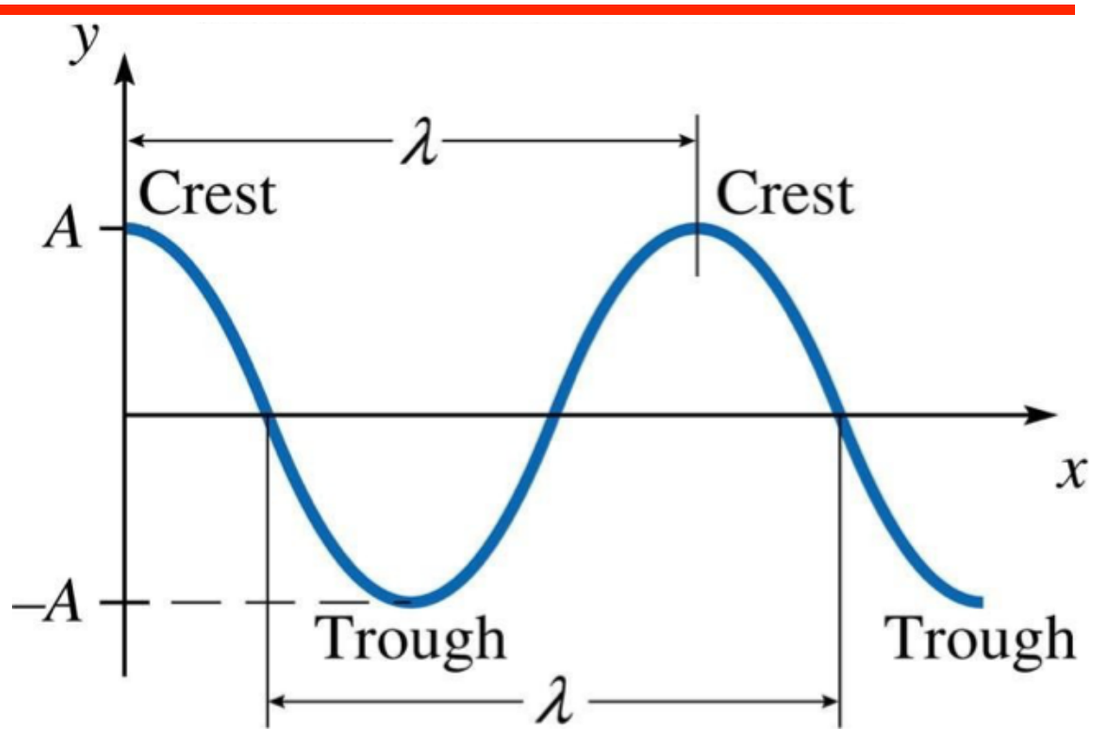
Importance of Electromagnetic Spectrum



- The behavior of an electromagnetic wave in a substance depends on its frequency or wavelength.
- The differing behaviors of different groups in the electromagnetic spectrum make them suitable for a range of uses.

Light Wave

- One way to determine the wavelength is by measuring the distance between two consecutive crests.
- The maximum displacement from equilibrium is amplitude (A) of a wave.



A periodic wave repeats the same pattern over and over.

For periodic waves: $v = \nu\lambda$

v is the wave's speed

ν is the wave's frequency

λ is the wave's wavelength

The period T is measured by the amount of time it takes for a point on the wave to go through one complete cycle of oscillations.

The frequency is then $\nu = 1/T$

Phase and Path Difference

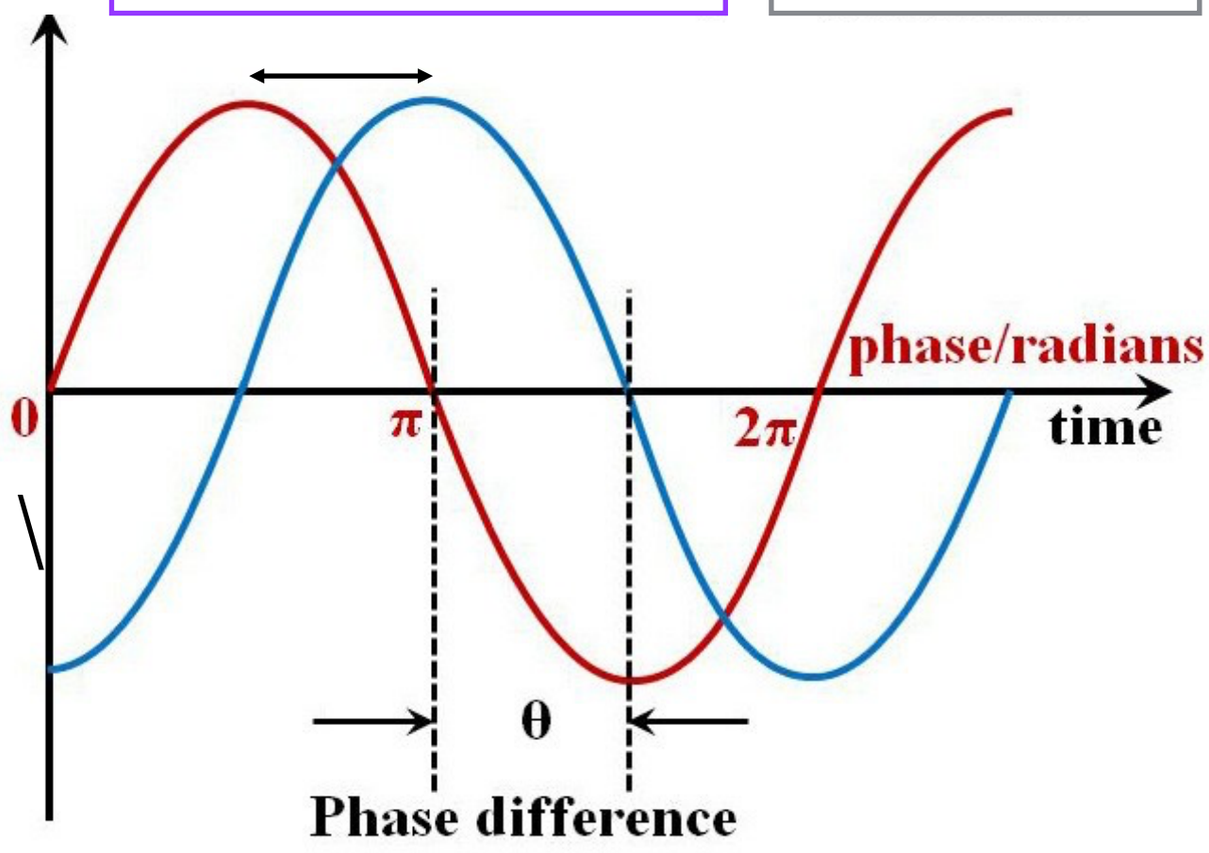
Phase Difference: It is the difference in phase angle between two points of a wave. It is measured in radian.

Path difference: It is the distance between two pints of a wave. it measured in m, mm, nm

$$\text{Path difference} = \frac{\lambda}{2\pi} \times \text{phase difference}$$

Path difference=$\lambda/4$
phase difference=$\Pi/2$

$y=A\sin(\omega t)$
$y=A\sin(\omega t-\Pi/2)$

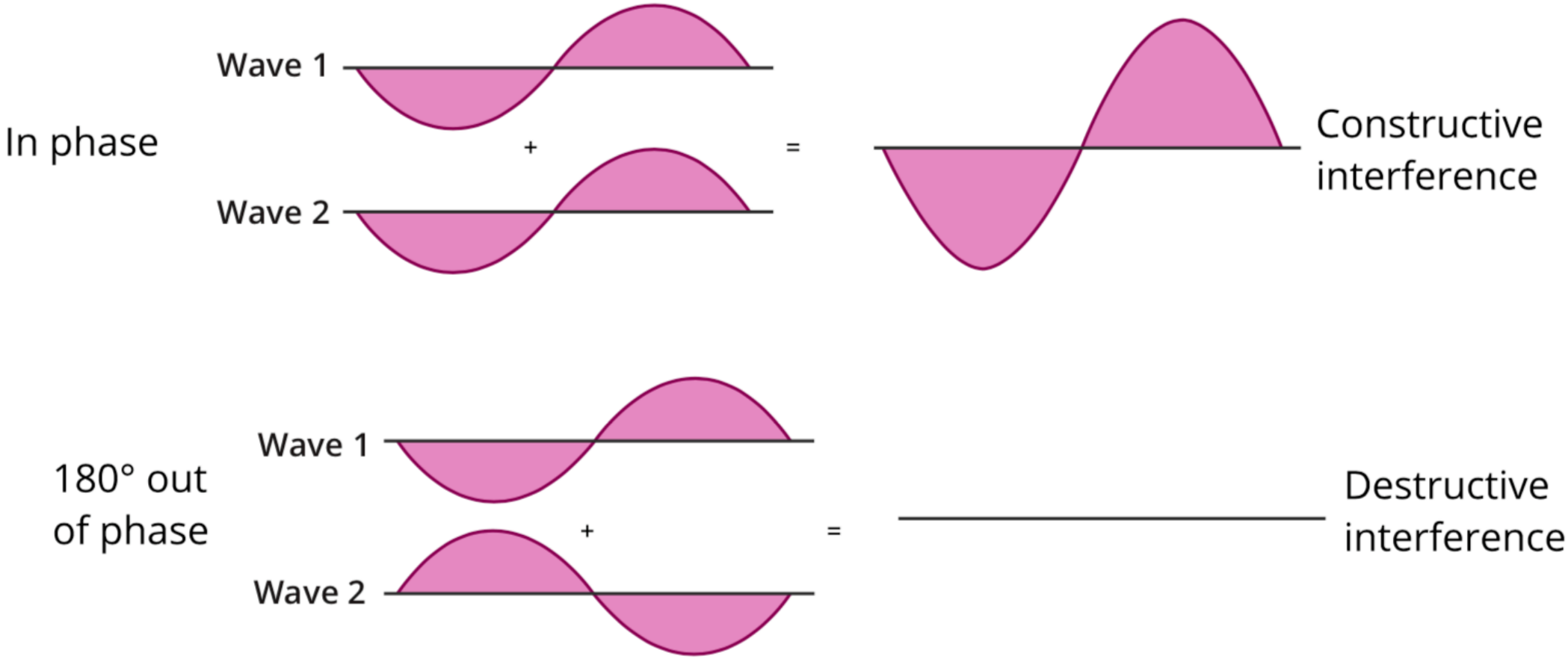


Beauty in Nature

Interference of Light

- Interference is the optical phenomenon. In nature many times we can see the interference.
- Interference is due to the superposition principle.
- "When two or more wave with constant phase difference, same intensity and same amplitude travelling from medium each wave produces its own displacement irrespective of each other. The resultant of these waves is the vector sum of the amplitude of each wave".
- "The modification or the redistribution of intensity of resultant wave due to superposition of two or more waves is known as interference".
- The bright colors seen in an oil slick floating on water or in a sunlight soap bubble are caused by interference. The brightest colors are those that interfere constructively.

Superposition Principle



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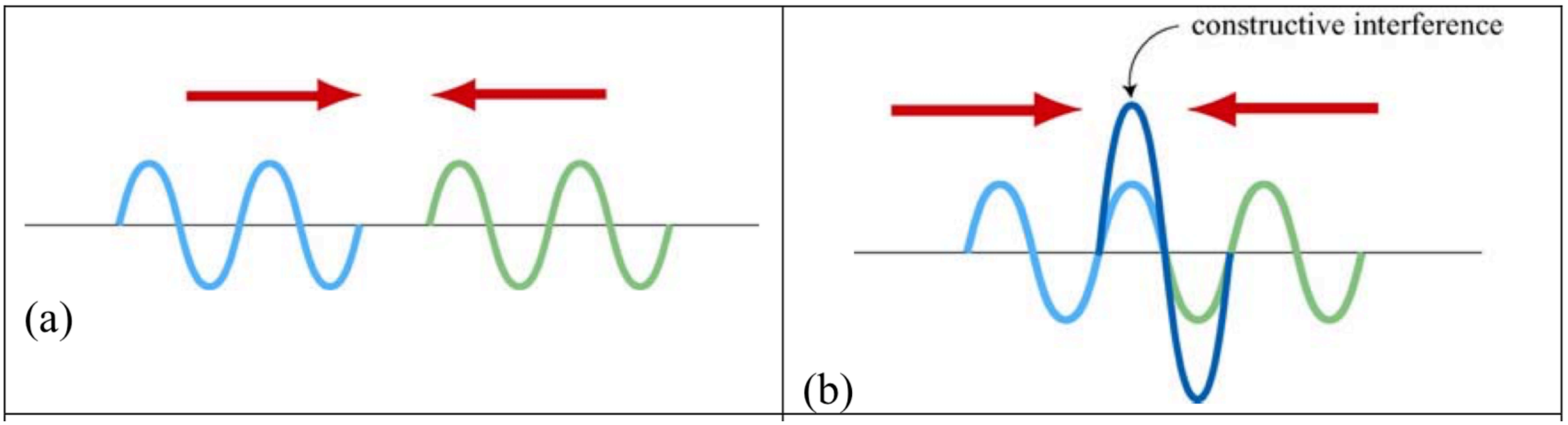
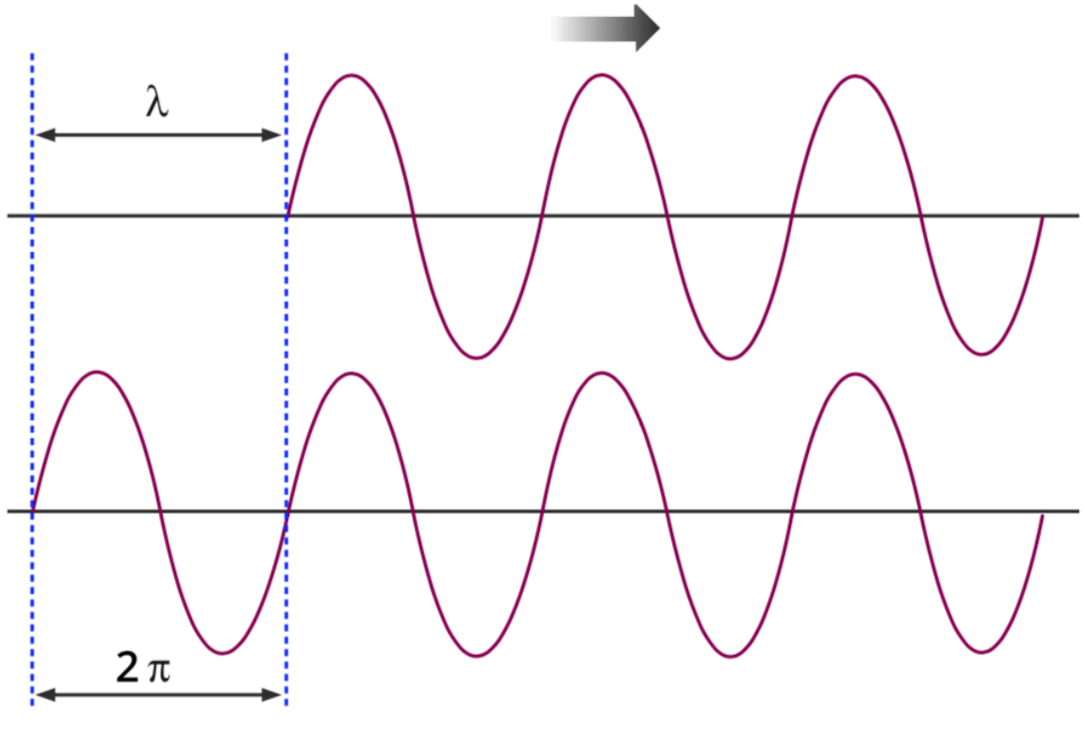
Constructive Interference

- At certain points waves superimpose in such a way that resultant intensity is greater than the intensities due to individual waves. The interference produced at these points is known as constructive interference.
- When the crest or trough of one wave coincides with crest or trough of another wave then resultant intensity become maximum and this is constructive interference.
- For constructive interference, the two waves must be in phase or having the same phase difference.



Constructive Interference



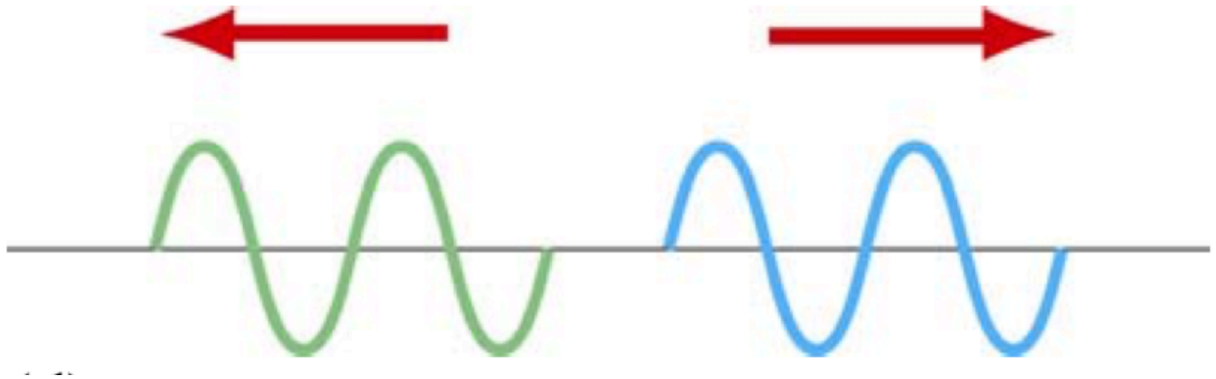
- For constructive interference (maxima), Phase difference = 0, 2π, 4π.....
- The phase difference of 2π corresponds to the path difference of λ.

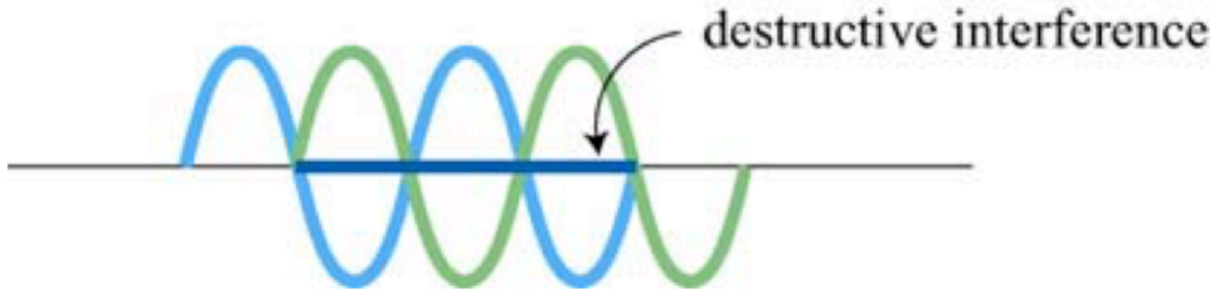
  Path difference = 0, λ, 2λ, 3λ...

  = nλ
- Thus, if the path difference between two waves is an integral multiple of the wavelength, then it produces the constructive interference or maxima.

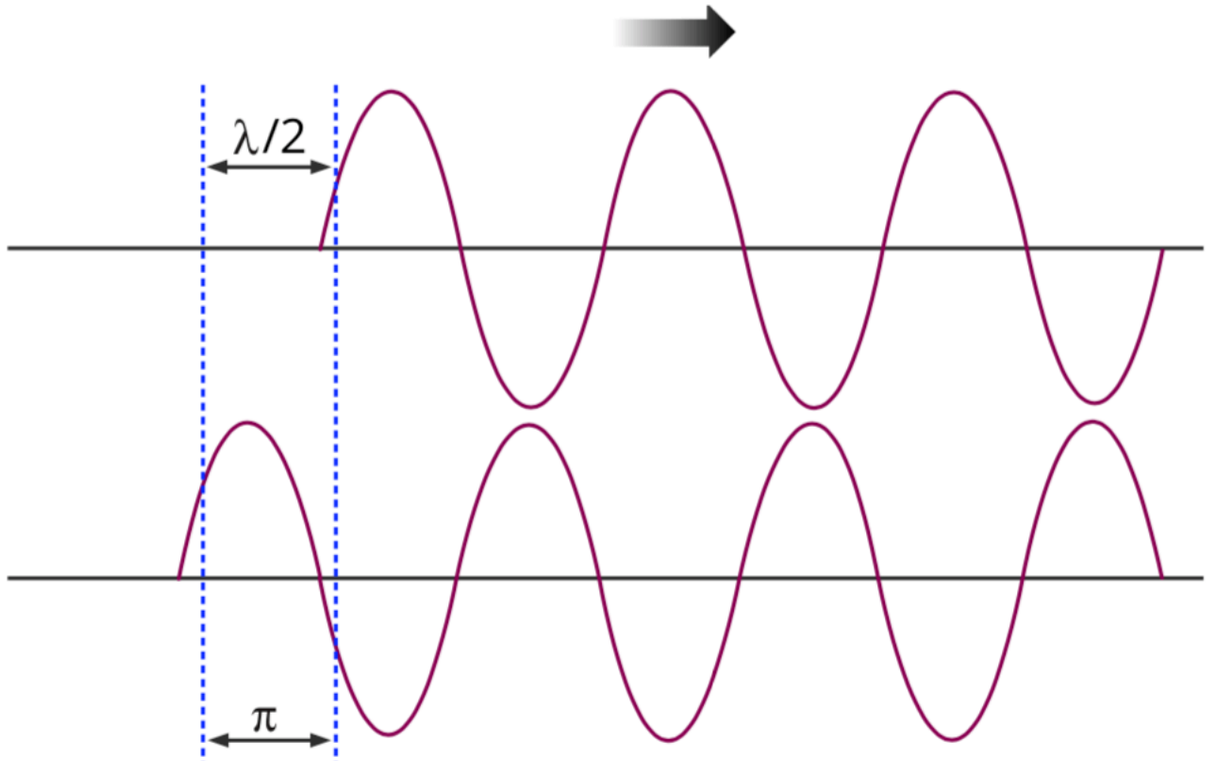
Destructive Interference

- At certain points waves superimpose in such a way that resultant intensity is less than the intensities due to individual waves. The interference produced at these points is known as destructive interference.
- When the crest of one wave coincides with trough of another wave then resultant intensity become minimum and this is destructive interference. For destructive interference, the two waves must be out phase or having different phase difference.





Destructive Interference



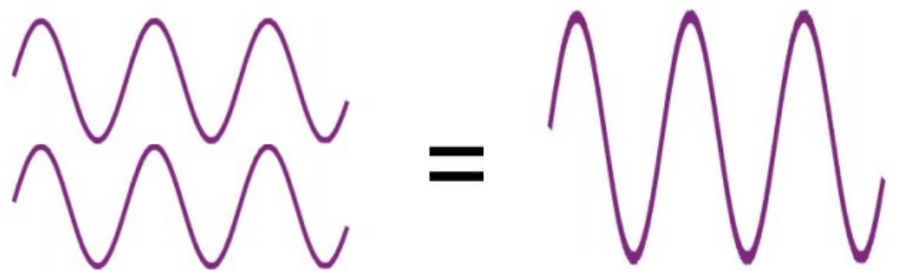
- For destructive interference (minima), Phase difference = 0, π, 3π, 5π .....
- The phase difference of π corresponds to the path difference of $\frac{\lambda}{2}$.
- Path difference $= 0, \frac{\lambda}{2}, \frac{3\lambda}{2}, \frac{5\lambda}{2} \ldots$

$$= (2n \pm 1)\frac{\lambda}{2}$$

- Thus, if the path difference between two waves is an odd integral multiple of half of the wavelength, then it produces the destructive interference or minima.

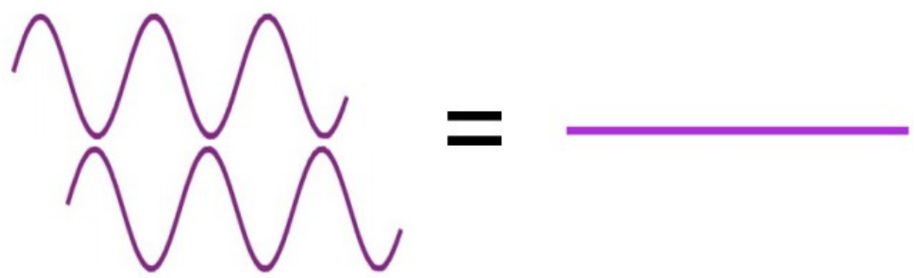
Destructive Vs Constructive Interference

Waves that combine **in phase** add up to relatively high irradiance.



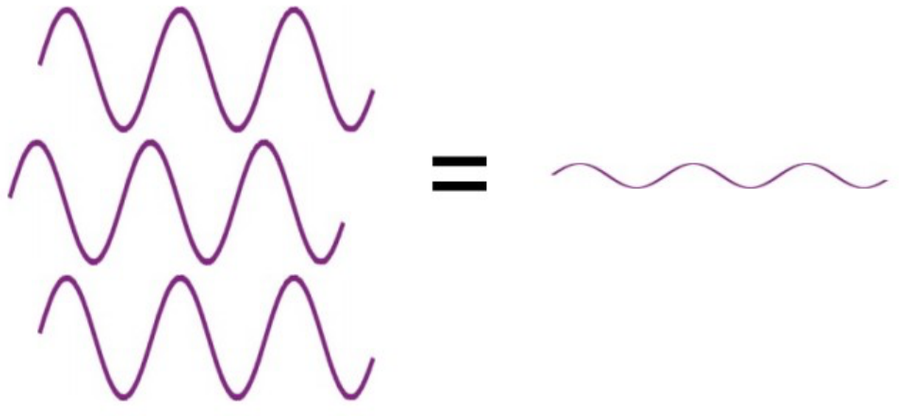
Constructive interference (coherent)

Waves that combine **180° out of phase** cancel out and yield zero irradiance.



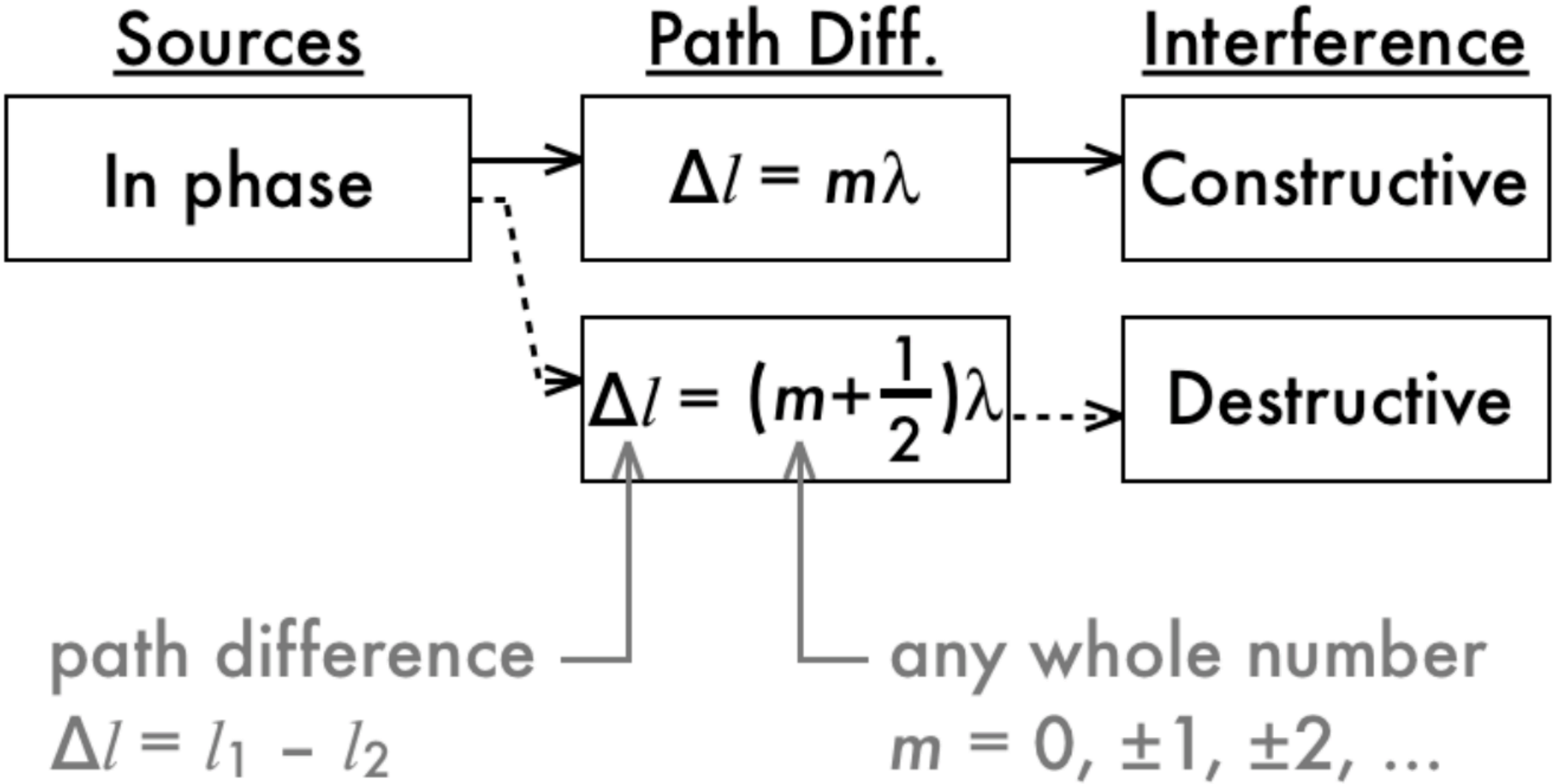
Destructive interference (coherent)

Waves that combine with **lots of different phases** nearly cancel out and yield very low irradiance.



Incoherent addition

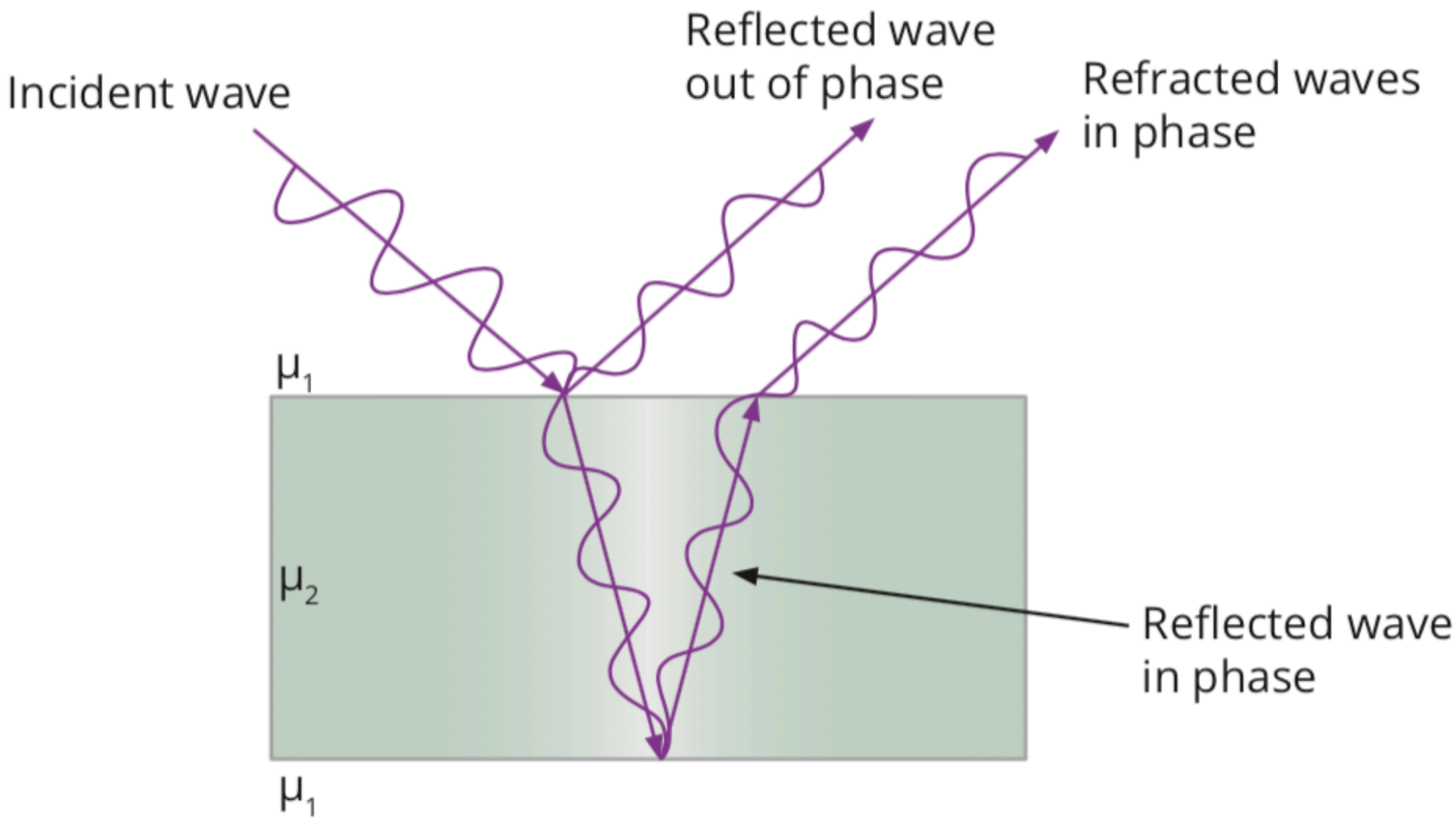
Destructive Vs Constructive Interference



Stokes Law

Stokes law states that

- Phase change of π or path difference ($\lambda/2$) occurs when light waves are reflected at the surface of the denser medium.
- No change of phase occurs when light waves are reflected at the surface of a rarer medium.



Thank You