**Wave Packets**

* A wave packet refers to the case where two (or more) waves exist simultaneously.
* It is also referred to as a wave group or "envelope" of localized wave action that travels as a unit.

*\*\*Schematic Diagram of Modulated amplitude (“Beats”)*

**Principle of Superposition:** If any two waves are a solution to the wave equation, then the sum of the waves is also a solution. This principle holds true only for linear systems.

**Coherent and Incoherent Sources:**

Wave packets can be formed by the superposition of two (or more) different waves of slightly different frequencies and wavelength which means waves having phase differences.

* **Coherent source**: emit waves having the same frequency, wavelength and in the same phase or they have a constant phase difference.
* **Incoherent sources:** emit waves that have random frequencies and phase differences.

Therefore, wave packets cannot be formed in coherent sources of light.

|  |  |  |
| --- | --- | --- |
| **Sunlight** | **LED (Light Emitting Diode)** | **LD (Laser Diode)** |
| Incoherent | Incoherent | Coherent |
| Wave packets exist | Wave packets exist | Wave packets do not exist |
| Polychromatic | Monochromatic | Monochromatic |

**Localisation of wave:**

According to deBroglie’s uncertainty principle:

* A sine wave of wavelength λ implies that the momentum is precisely known but the position of particle in the wave is uncertain.
* As the number of waves increases, the wave packet becomes more localized in space but momentum is uncertain.

*\*\*Δx and λavg diagram*

**Phase Velocity (Vp) and Group Velocity (Vg)**

**Phase Velocity (Vp):**

* The phase velocity of a wave is the rate at which the wave propagates in any medium.
* This is the velocity at which the phase of any one frequency component of the wave travels.
* **, ,**

**Group Velocity (Vg):**

* The group velocity of a wave is the velocity with which the overall wave packet (envelope) propagates through space.
* Each envelope contains a group of internal waves.

In a given medium, the frequency is some function, w(k), of the wave number. Therefore, phase velocity and group velocity depend on the frequency and the medium.

*\*\* Schematic diagram of wave packet, Vp and Vg*

**Relation between Phase Velocity and Group Velocity:**

*\*\* Derivation for relation here*

Therefore, if the phase velocity does not depend on the wavelength of the propagating wave, then Vg = Vp. This happens in non-dispersive media.

**Wave patterns:**

The wave patterns for various values of Δω and Δk will not be same even if Vg is same for the different waves. The resultant wave formed by the superposition of two waves is dependent on the values of Δω and Δk independently.

*\*\* Insert simulation image here*