CL36_Q1. Explain why a laser is not a perfectly momochromatic source.

Ans:

Laser light is not a perfectly monochromatic source, because the spectral emission line from which it originates does have a finite width. Since the wavelength of the light is extremely small compared to the size of the laser cavities used, then within that tiny spectral bandwidth of the emission lines are many resonant modes of the laser cavity. The emission line widths are also limited by the uncertainty principle which limits the accuracy of the energy (ΔE) of the photons emitted by electrons which spend times with a spread in time (Δt). Generally LASER line widths are very small of the order of 10^{-6} Å as compared to 1 Å for ordinary monochromatic sources.

CL36_Q2. Discuss any two properties of a laser that differentiate it from ordinary light sources.

Ans:

The most important properties of a LASER are Mono-chromaticity & Coherence -

<u>Mono-chromaticity:</u> Light from a laser typically comes from an atomic transition with a single precise wavelength. So the laser light has a single spectral color and is almost the purest monochromatic light available. However, the laser light is not truely monochromatic. The emission line widths are also limited by the uncertainty principle which limits the accuracy of the energy (ΔE) of the photons emitted by electrons which spend times with an spread in time (Δt).

<u>Coherence</u>: Coherence is a unique property of laser light. In the stimulated emission process triggered by a common, the emitted photons are "in phase" or have a definite phase relation to each other. This coherence is essential to produce high quality interference, which is used to produce holograms.

Coherence can be of two types' temporal coherence and spatial coherence.

<u>Temporal coherence</u>: refers to the correlation between the field at a point and the field at the same point after an elapse of time. If the phase difference between the two fields is constant during the period (of the order of micro seconds), the wave is said to have said to have temporal coherence.

Spatial coherence - Two fields at two different points of a wave front is said to be spatially coherent if they preserve a constant phase difference over any time t. Two beams of light originating from different parts of a source will have been emitted by different groups of atoms. Each beam will be time incoherent and will have random phase changes. Two such beams are said to be spatially incoherent. Spatial coherence is characteristic of two separate beam of light.

Ordinary light is incoherent because it comes from independent atoms, which emit on time scales of about 10^{-8} seconds. There is a degree of coherence in sources like the mercury green line and some other useful spectral sources, but their coherence does not approach that of a laser.

CL36_Q3. A laser beam emits a wavelength of 10.6 μm. If the duration of the pulse is 0.1 x10^{-6} s, calculate the coherence length and line width.

Ans:

$$L_{coh} = t_{coh} \times c$$

$$= 0.1 \times 10^{-6} \times 3 \times 10^{8} = 30\, m$$

Band width $\Delta\vartheta = \frac{1}{t_{coh}} = 10^{7}\ Hz$

$$\Delta\lambda = \frac{\lambda^2}{L_{coh}} = \frac{(10.6\times10^{-6})^2}{0.1\times10^{-6}} = 7.123\, nm$$