Laser

LASER stands for Light amplification by stimulated emission of radiation. Laser is a device which emits a powerful, monochromatic collimated beam of light. The emitted light waves are coherent in nature.

Characteristics of Laser

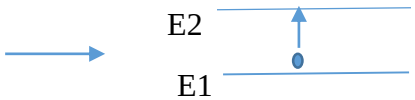
1. **Directionality**: Lasers emit light that is highly directional. Laser light is emitted as a relatively narrow beam in a specific direction. Ordinary light, such as coming from the sun, a light bulb, or a candle, is emitted in many directions away from the source.
2. **Monochromatic**: The light emitted from a laser is monochromatic, that is, it is of one wavelength (color). In contrast, ordinary white light is a combination of many different wavelengths (colors).
3. **Coherent:** The light from a laser is said to be coherent, which means the wavelengths of the laser light are in phase in space and time.
4. **Intensity:** Since an ordinary light spreads in all directions, the intensity reaching the target is very less. But in the case of laser, due to high directionality, the intensity of laser beam reaching the target is of high intense beam. For example, 1 mill watt power of He-Ne laser appears to be brighter than the sunlight.

These properties of laser light are what make it more of a hazard than ordinary light. Laser light can deposit a great deal of energy within a very small area.

Important term related to Laser

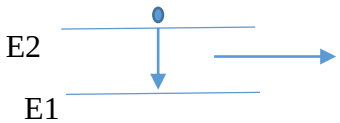
1.Absorption: An atom in a lower level absorbs a photon of frequency hν and moves to an upper level. Molecule absorbs a quantum of radiation (a photon) and is excited from 1 to 2.

$M + h\nu \rightarrow M^*$ (state 1) to.(state 2)



2.Spontaneous Emission: An atom in an upper level can decay spontaneously to the lower level and emit a photon of frequency hν if the transition between E2 and E1 is radiative. This photon has a random direction and phase. Spontaneous emission M* (in state 2) spontaneously emits a photon of radiation. Photons emitted in all directions and on a random time scale. So the emitted photons are INCOHERENT

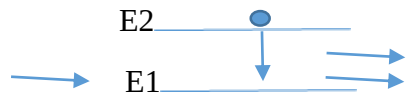
$M^* \rightarrow M + h\nu$



3.Stimulated Emission: An incident photon causes an upper level atom to decay, emitting a "stimulated" photon whose properties are identical to those of the incident photon. The term "stimulated" underlines the fact that this kind of radiation only occurs if an incident photon is present. The amplification arises due to the similarities between the incident and emitted photons. A quantum of radiation is required to stimulate M* to go from 2 to 1. Emitted and

stimulating photons have the same Frequency, Direction, and Phase. So the emitted and incident photons are COHERENT

$M^* + h\nu \rightarrow M + 2h\nu$



Rates of absorption and emission processes

Rates are determined by the Einstein coefficients for each process

$dN_1/dt=N_1 B_{12}D(\upsilon)$ absorption

$dN_2/dt=N_2 B_{21}D(\upsilon)$ Spontaneous emission

$dN_2/dt=N_2 A_{21}$ Stimulated emission

B_{12}, B_{21}, and A_{21} is known as Einstein coefficients. $D(\upsilon)$ is the energy density of the incident radiation and N1 and N2 are the populations of states 1 and2 respectively. Under thermal conditions the population of two states 1 and 2, is determined by the Boltzman distribution

$N_2/N_1=\exp(-\Delta E/KT)$

First condition for laser action:

If N1 > N2

If most molecules in state 1, then incoming radiation is mainly absorbed then Incident radiation is attenuated (reduced)

If N2 > N1

If most molecules are in state 2, absorption of incoming radiation is slowed down so the result is stimulated emission. Therefore, Incident radiation is amplified. Thus for laser action require a population inversion, N2 > N1

Link for Laser 1. https://youtu.be/BKVMw4jpDZw
2. https://youtu.be/QlVDFZDL2Ho

3 https://youtu.be/iWaAPwsrJhg

4.https://youtu.be/1LmcUaWuYao