LASER AND ITS PROPERTIES

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LASERS

The LASER is invented in 1958 by Charles Townes (Nobel prize in Physics 1964) and Arthur Schawlow of Bell Laboratories based on theoretical work by Charles Hard Townes and Arthur Leonard Schawlow.

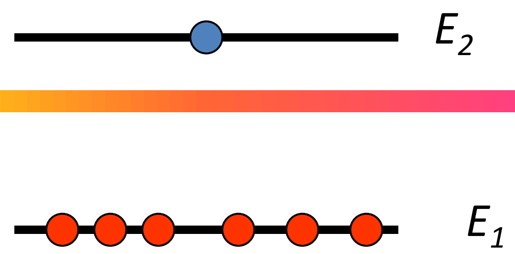
• It is based on Einstein's idea of the "particlewave duality" of light, more than 30 years earlier
• Originally called MASER (m = "microwave")

LASER

Laser is generally known as the light amplification by Stimulated Emission of Radiation

- In other word LASER is the acronym for light amplification though stimulated emission of radiation.
- However, laser is a not a simple amplifier of light but is actually a generator of light.
- A device produces a coherent beam of optical radiation by stimulating electronic, ionic, or molecular transitions to higher energy levels
- When they return to lower energy levels by stimulated emission, they emit energy.

Condition for the laser operation



If $n_1 > n_2$

- radiation is mostly absorbed absorbowane
- spontaneous radiation dominates.

if $n_2 >> n_1$ - *population inversion*

- most atoms occupy level E2, weak absorption
- stimulated emission prevails
- light is amplified

Necessary condition:
population inversion

Properties of LASER

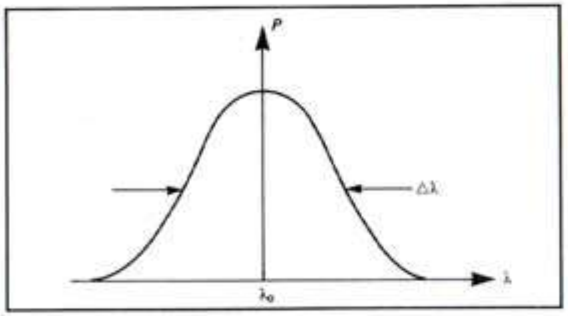
- The light emitted from a laser is monochromatic, that is, it is of one color/wavelength. In contrast, ordinary white light is a combination of many colors (or wavelengths) of light.

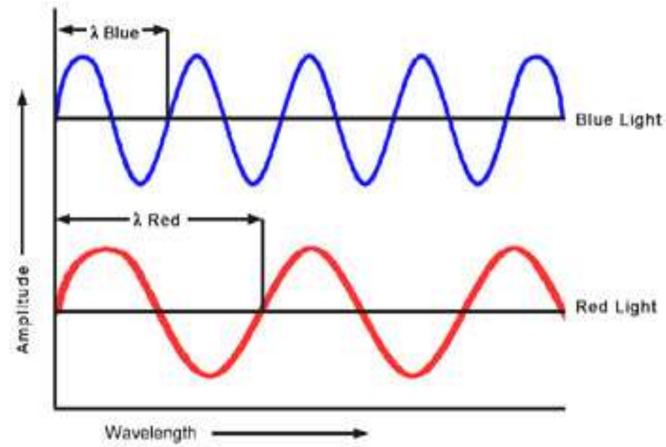
- Lasers emit light that is highly directional, that is, laser light is emitted as a relatively narrow beam in a specific direction. Ordinary light, such as from a light bulb, is emitted in many directions away from the source.

- The light from a laser is said to be coherent, which means that the wavelengths of the laser light are in phase in space and time. Ordinary light can be a mixture of many wavelengths.

These three properties of laser light are what can make it more hazardous than ordinary light. Laser light can deposit a lot of energy within a small area.

MONOCHROMACITY

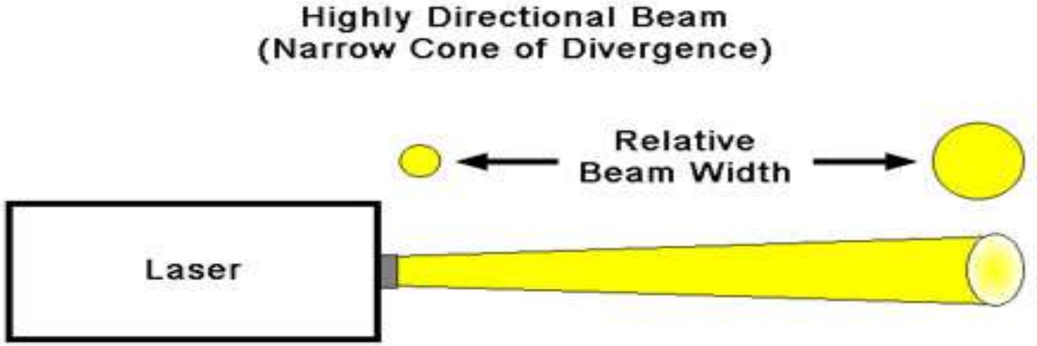




Nearly monochromatic light
Example:
He-Ne Laser
$\lambda 0 = 632.5$ nm
$\Delta\lambda = 0.2$ nm
Diode Laser
$\lambda 0 = 900$ nm
$\Delta\lambda = 10$ nm

Comparison of the wavelengths of red and blue light

Directionality



Conventional light source Divergence angle (θd)

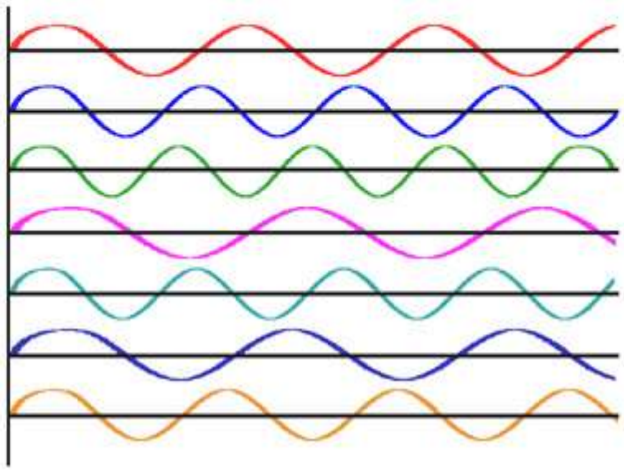
Beam divergence: $\theta d = \beta \lambda / D$

$\beta \sim 1$ = f(type of light amplitude distribution, definition of beam diameter)

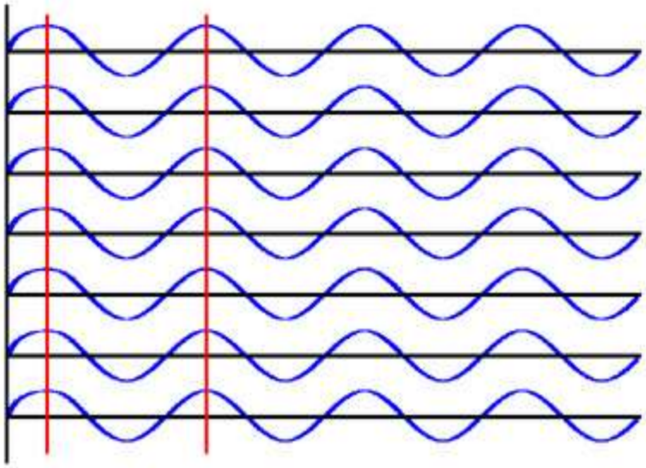
λ = wavelength

D = beam diameter

Coherence



Incoherent light waves

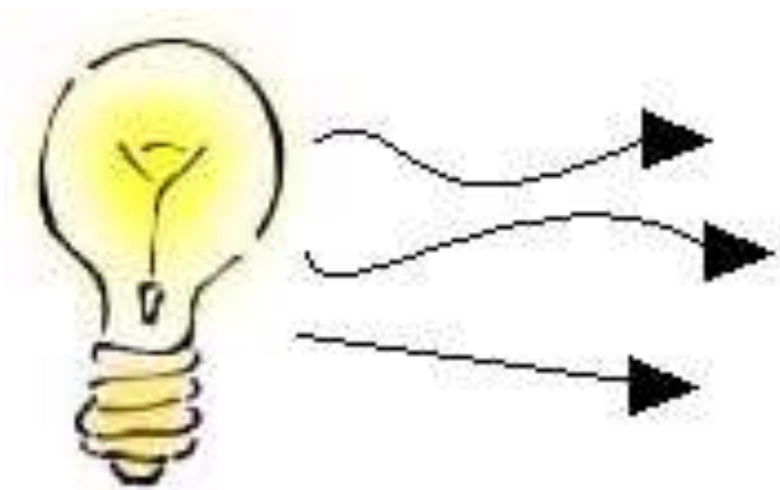


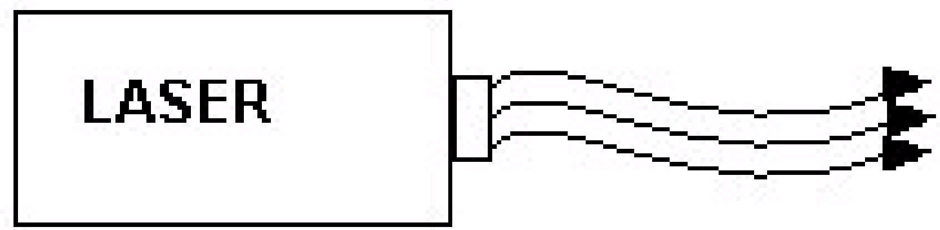
Coherent light waves

Basic concepts for a laser

- Absorption
- Spontaneous Emission
- Stimulated Emission
- Population inversion

Incandescent vs. Laser Light



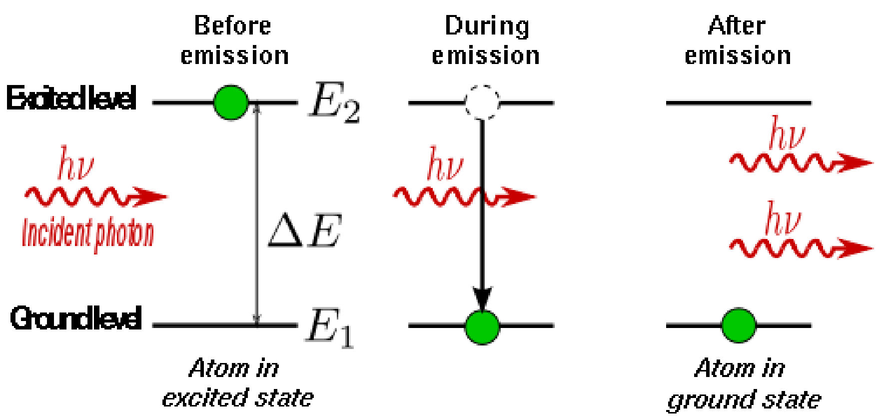


1. **Many wavelengths**
2. **Multidirectional**
3. **Incoherent**

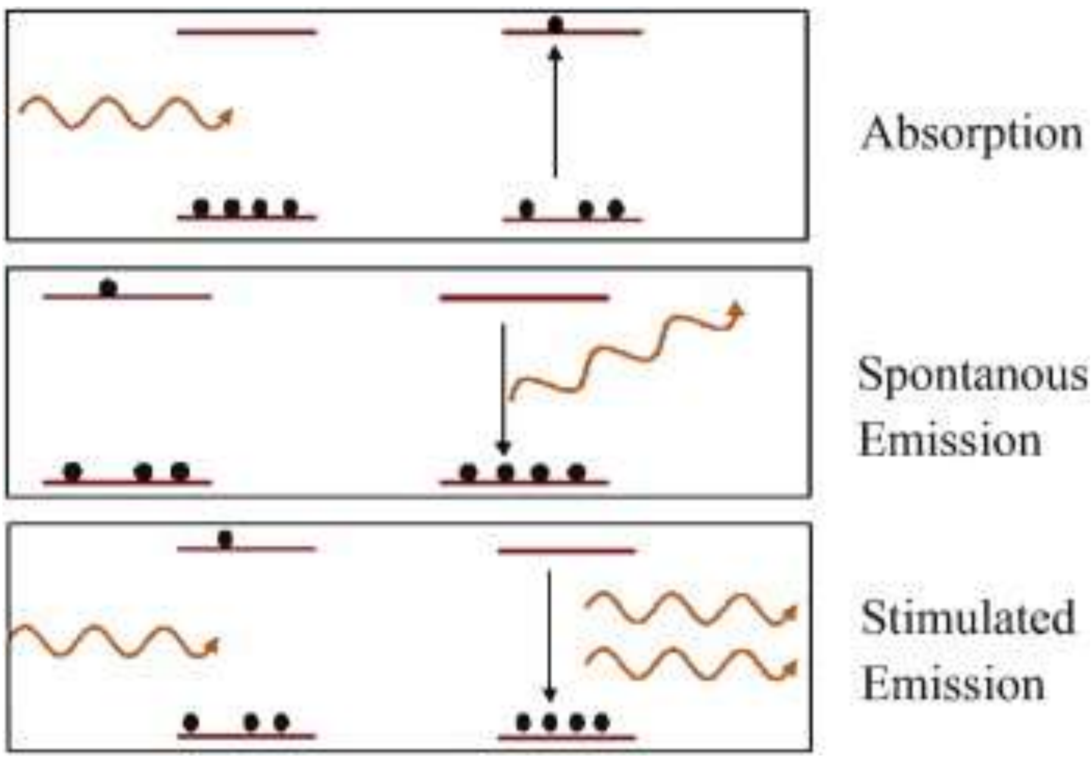
1. **Monochromatic**
2. **Directional**
3. **Coherent**

diation.
When an atom jumps from a higher energy stated to a lower energy

Spontaneous Emission



$$E_2 - E_1 = \Delta E = h\nu$$



Energy is absorbed by an atom, the electrons are excited into vacant energy shells because

The atom decays from level 2 to level 1 through the emission of a photon with the energy *hv*. It is a completely random process.

atoms in an upper energy level can be triggered or stimulated in phase by an incoming photon of a specific energy

POPULATION INVERSION

- A state in which a substance has been energized, or excited to specific energy levels.
- More atoms or molecules are in a higher excited state.
- The process of producing a population inversion is called pumping.
- Examples:

→by lamps of appropriate intensity

→by electrical discharge

PUMPING

•Optical: flashlamps and high-energy light sources

•Electrical: application of a potential difference across the laser medium

•Semiconductor: movement of electrons in “junctions,” between “holes”

Einstein coefficients

- The Einstein coefficient are the proportionality constants introduced in this discussed
- (i)The probability that an absorption transition occurs is given by
- $P_{12}=B_{12}\ \rho(v)$
- Where B_{12} is constant of
- absorption transition occurs is given by proportionality known as the Einstein coefficient for induced absorption . It is a constant characteristics of the atom and represents the properties of the energy states E_1 and E_2.
- (ii) the probability that a spontaneous transition occurs is given by
- $(P_{21})_{spontaneous} = A_{21}$
- where A_{21} is a constant kwon as the Einstein