18PYB101J MODULE-5 LECTURE 3

- Threshold population inversion
- Essential components of a Laser system
- Pumping mechanisms
- Types of Lasers

Threshold population inversion

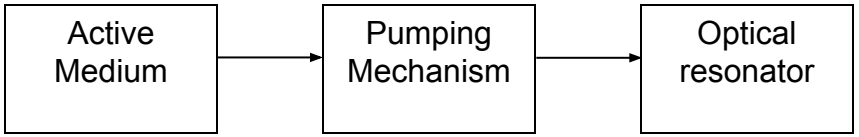
- For a medium to amplify an incident radiation, one must create a state of population inversion in the medium.

- Such a medium will behave as an amplifier for those frequencies, which will fall within its line width. In order to generate radiation this amplifying medium is placed in an optical resonator, which consists of a pair of mirrors facing each other.

- Radiation, which bounces back and forth between the mirrors, is amplified by the amplifying medium and also suffers losses due to the scattering by the medium, diffraction due to finite mirror sizes etc.

If the oscillation has to be sustained in the cavity then the losses must be exactly compensated by the gain. Thus a minimum population inversion density is required to overcome the losses and this is called the *threshold population inversion*.

Essential components of a laser system



Active medium or Gain medium

It is the system in which population inversion and hence stimulated emission (laser action) is established.

Pumping Mechanism

It is the mechanism by which population inversion is achieved.

i.e., it is the method for raising the atoms from lower energy state to higher energy state to achieve laser transition.

Different pumping mechanisms

i. Optical pumping

Exposure to electromagnetic radiation of frequency $\upsilon = (E_2-E_1)/h$ obtained from discharge flash tube results in pumping

Suitable for solid state lasers

ii. Electrical discharge

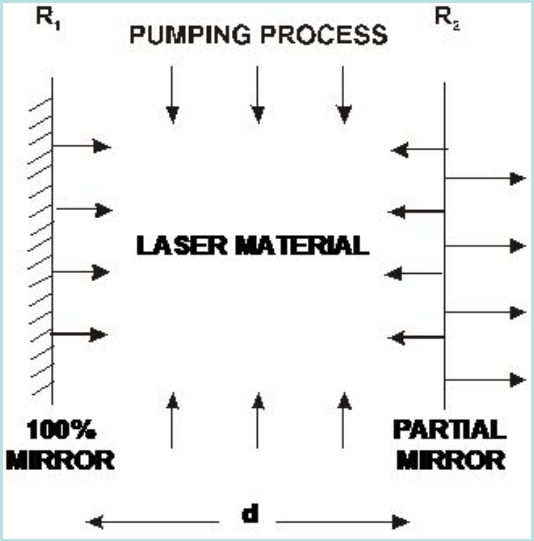
By inelastic atom-atom collisions, population inversion is established

Suitable for Gas lasers

iii. Chemical pumping

By suitable chemical reaction in the active medium, population of excited state is made higher compared to that of ground state

Suitable for liquid lasers.



Optical Resonator

A pair of mirrors placed on either side of the active medium is known as optical resonator. One mirror is completely silvered and the other is partially silvered. The laser beam comes out through the partially silvered mirror.

Laser action summary

Step 1 : Choose a proper lasing medium

Step 2 : Establish population inversion by suitable pumping

Step 3 : Stimulated emission takes place

Step 4 : Positive feed back (optical resonator)

Step 5 : Amplification of light

Types of Lasers

Based on its pumping action

- Optically pumped laser
- Electrically pumped laser

Basis of the operation mode

- Continuous wave Lasers
- Pulsed Lasers

According to their wavelength

- Visible Region
- Infrared Region
- Ultraviolet Region
- Microwave Region
- X-Ray Region

According to the source

- Dye Lasers
- Gas Lasers
- Chemical Lasers
- Metal vapour Lasers
- Solid state Lasers
- Semi conductor Lasers

Typical Lasers

Laser gain medium and type	Operation wavelength(s)	Pump source	Applications and notes
Carbon dioxide laser	10.6 μm, (9.4 μm)	Transverse (high power) or longitudinal (low power) electrical discharge	Material processing (cuttingMaterial processing (cutting, weldingMaterial processing (cutting, welding, etc.), surgery.
Nd:YAG laser	1.064 μm, (1.32 μm)	Flashlamp, laser diode	Material processing, rangefinding, laser target designation, surgery, research, pumping other lasers (combined with frequency doubling to produce a green 532 nm beam). One of the most common high power lasers. Usually pulsed (down to fractions of a nanosecond)
Semiconductor laser	0.4-20 μm, depending on active region material.	Electrical current	TelecommunicationsTelecommunications, holographyTelecommunications, holography, printing, weapons,

Typical Lasers (Contd…)

AlGaAs	0.63-0.9 μm	Electrical current	Optical discsOptical discs, laser pointersOptical discs, laser pointers, data communications. 780 nm Compact Disc player laser is the most common laser type in the world. Solid-state laser pumping, machining, medical.
InGaAsP	1.0-2.1 μm		Telecommunications, solid-state laser pumping, machining, medical..