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Pumping

Need For Pumping :-

For realizing and maintaining the condition of population inversion the atoms have to be raised continuously to the excited state. It requires energy to be supplied to the system. The process of supplying energy to the medium with a view to transferring it into the state of population inversion is known as pumping.

One should bear in mind that heating the material will not bring about population inversion. Thermal energy will only heat up the collection of atoms and all of them maintaining the same population ratio will just gain more heat energy.

The pumping process in lasers involves a number of energy levels with complicated excitation mechanisms.

Atoms :- Helium Neon (He-Ne) laser, helium Cadmium (He-Cd) laser, Copper Vapour lasers

Molecules :- Carbon dioxide (CO_2) laser, ArF and KrF excimer laser, N_2 laser.

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Liquids :- Organic dye molecules, dilutely dissolved in various solvent solutions.

Dielectric Solids :- Neodymium ions doped in YAG or glass to make Crystalline Nd:YAG or Nd:Glass lasers.

Semiconductor materials :- Gallium Arsenide, Indium Phosphide Crystals.

The medium in which light gets amplified is called active medium. The medium may be solid, liquid or a gas. Out of the different atoms in the medium only a small fraction of atoms of particular species are responsible for stimulated emission and consequent light amplification. They are called active centres. The remaining bulk of material plays the role of a host and supports active centres. The population inversion happens only in the active centres of the medium and pumping process should be such that the maximum input energy should be

targetted to the active centres.

Because of the consequces of the Einstein's theory, radiation grows in intensity as it passes ~~through~~ through the active medium.

Pumping Methods

According to requirement, diverse methods of pumpig are used.

Types of Laser	Pumping mechanism
Gas Lasers (He-Ne, Argon Ion)	AC or DC electrical Discharge throgh Gas medium
Solid Stat Lasers (Ruby, Nd:YAG)	Optical Pumping High energy Xenon flashlamp.
Liquid Lasers (Dye)	Optical Pumping.
Free electron lasers	Particle Accelerators.

Optical Pumpig :-

In this method, photons are used to excite the atoms A light source such as flash discharge lube is used illuminate the laser medium and the photons

of appropriate frequency excite the atoms to an uppermost level. The optical pumping source can be any one of the various types of flash discharge tubes such as continuously operated lamps, flash tubes, spark gaps or auxiliary laser etc.

Optical Pumping is used for solid state crystalline lasers and liquid tunable dye lasers. The pumping level of the atom must not be of narrow level. It should be sufficiently large/wide, spanning a range of energies. If it is narrow, one can use pumping of only specific frequency such a situation severely restricts the choice of source and a large portion of source power will go wasted.

However in majority of cases the upper levels are wide bands and atoms can be excited to many of the upper levels. Therefore light sources emitting a broad range of wavelengths like flash lamps can be used to excite the atoms.

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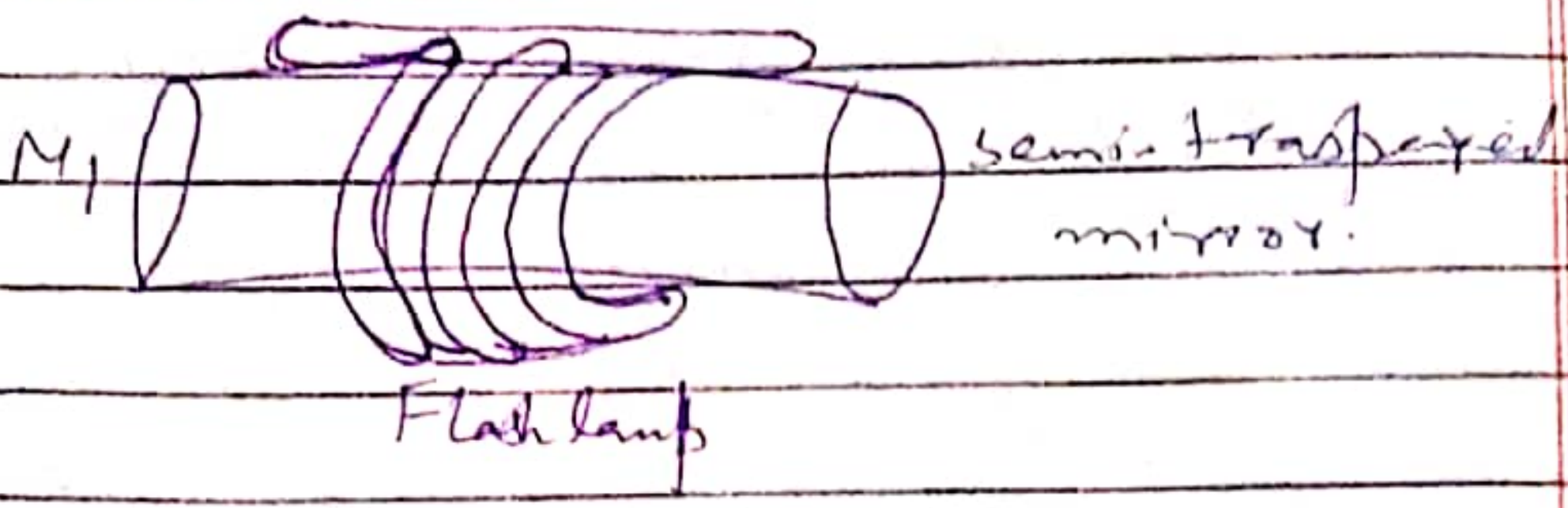

Optical pumping in ruby laser.

First successful optical laser constructed by Maiman (1960) consisted of ruby crystal surrounded by a helical/helicoidal flash lamp/tube enclosed within a polished aluminium cylindrical cavity cooled by forced air.

Optical Pumping in Ruby laser

The most common configuration is the gain medium is in the form of rod located at one of focus of a mirrored cavity, consisting of an elliptical cross-section perpendicular to the rods axis. The flash lamp is Tube located at other focus of the ellipse.

Electric Pumping

Direct Discharge:-

In this medium is placed in an electron beam the electrons excite a population inversion by transfering their energy to the atom they collide. Consequently the atoms are ionized and emission is produced. Several types of High power lasers (gas lasers) are pumped this way examples are

Argon gas laser

N_2 laser.

P-n Junction laser:-

Another variation of electric pumping creates a population inversion in semiconductor diode lasers. When a current passes through the interface between two different types of semiconductors, it creates mobile charge carriers. If enough of these are created, they can produce a population inversion.

The p-n junction lasers are called injection lasers.

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Inelastic atom-atom Collisions

The atoms excited by electrical discharge method collide inelastically with other atoms, transferring their energy in the process. Population inversion is produced in the other atoms

He-Ne and CO_2 lasers are examples of this kind.

Chemical Pumping

In chemical pumping, the energy for pumping is obtained from a chemical reaction.

As an example

When Hydrogen combines with Fluorine to form Hydrogen fluoride, enough heat is generated.

This reaction is employed for pumping in HF and DF lasers.