LASER TECHNOLOGY PART --II

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LASER

(LIGHT AMPLIFICATION BY STIMULATED EMISSION OF RADIATION)

- Invented in 1960
- It is a device by which an intense, monochromatic, collimated and highly-coherent light beam can be obtained.
- Main components :

1. working substance having metastable state.
2. Resonant cavity.
3. Pumping system

Principle

- Normally, the atoms of a substance are in their ground state.
- When they are given energy by some external source, they are excited and reach some higher-energy state.
- An atom can persist in an excited state only for 10^{-8} second (lifetime of atom) after which it returns to its normal state.
- Atom emits light photons of frequency v, where

$$h\nu = E1 - E2$$

- where E1 & E2 are the energies in the lower energy and higher energy states respectively.
- Process is called spontaneous emission.
- This is irregular emission and takes place at different times for different atoms.
- Light obtained by spontaneous emission from different atoms is incoherent.
- When atom is in an excited state E2, a light photon of the same frequency which is to be emitted by the atom, falls upon it, then the atom immediately comes down to its normal state E1 and stimulates the incident light by emitting the photon of exactly the same frequency called stimulated emission.

- It occurs long before the spontaneous emission.
- Emitted stimulated light is completely coherent with the incident light.
- Stimulated and incident light photons cause coherent stimulated light emission from other excited atoms.
- If substance has a good number of excited atoms, then this process gets multiplied.
- Thus, an intense, coherent light beam is emitted from the substance.
- Various means are adopted to raise the atoms from normal state to the excited state.
- This process is called Pumping.
- Ex: Ruby laser, Gas laser, semiconductor laser.

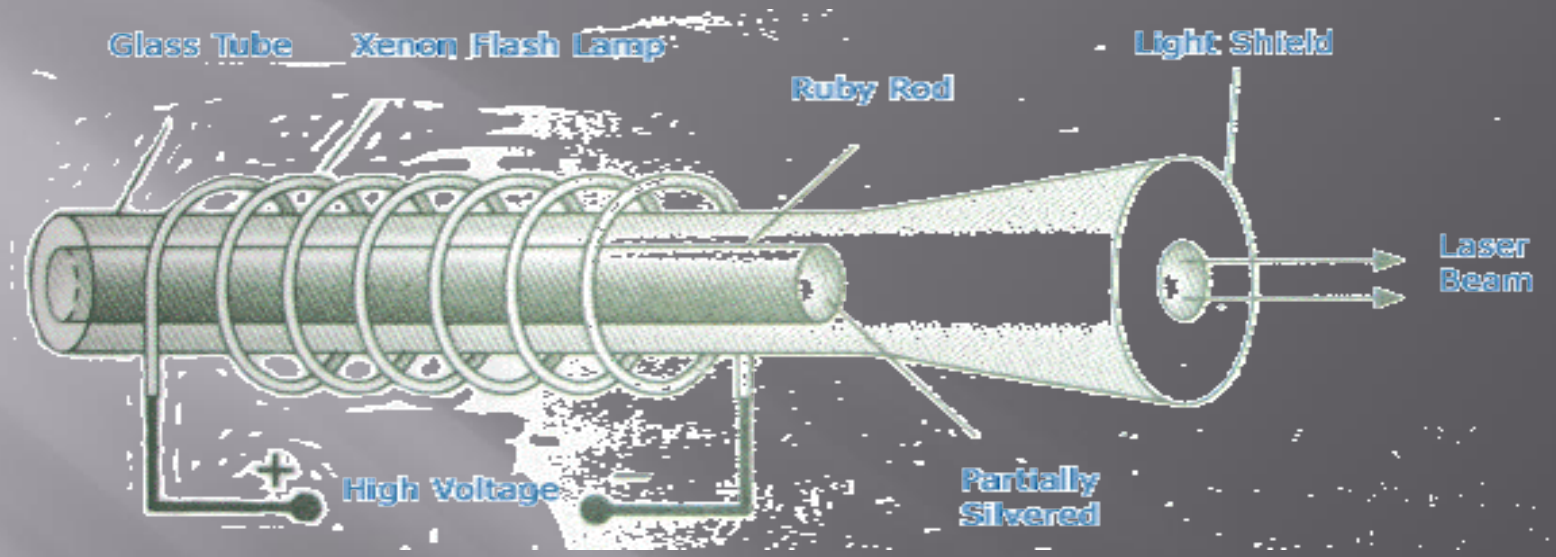
Ruby Laser (A Solid State Laser)

- It is the first operating laser using three energy level scheme of population inversion.
- It consist of three parts:

i. The working substance; in the form of a rod of ruby crystal.

ii. The resonant cavity mode of a fully reflecting plate at the left and a partially reflecting plates at the right, both optically plane & accurately parallel.

iii. The optical pumping system consisting of a helical xenon discharge tube.



- Ruby cylindrical rod is surrounded by a glass tube.
- Glass tube is surrounded by a helical xenon flash tube which acts as the optical pumping system.
- Ruby rod is a crystal of Aluminium oxide (Al_2O_3) doped with 0.05 % chromium oxide (Cr_2O_3).
- So some of the aluminium atoms in the crystal lattice are replaced by Cr^{3+} ions.

- Cr^{3+} ions are excited from level E1 to level E2 by the absorption of light of wavelength 550 nm from the xenon discharge tube.
- Excited ions quickly undergo non-radiative transitions with a transfer of energy to the lattice thermal motion to the level E2.
- E2 level is metastable state with a life time of about 3×10^3 sec.
- Now, the population of the level E2 becomes greater than that of the level E1.
- Thus, Population Inversion is achieved.

- Some photons are produced by spontaneous transition from E2 to E1 and have a wavelength of 694.3 nm (ruby rod).
- Photons that are not moving parallel to the ruby rod escape from the side, but those moving parallel to it are reflected back.
- Ends of the ruby rod acts as a reflecting plate.
- These stimulates beam of photons all moving parallel to the rod which is monochromatic and coherent.

- When the beam develops sufficient intensity, it emerges through the partially reflecting rod.
- Once all the chromium ions in the metastable level have returned to ground level, the laser action stops.
- It is then necessary to send one more flash of pumping radiation through the rod.
- Thus, the ruby laser operates only in pulses.

THANK YOU

Alos see Part III