LASER

From the desk of

DATE

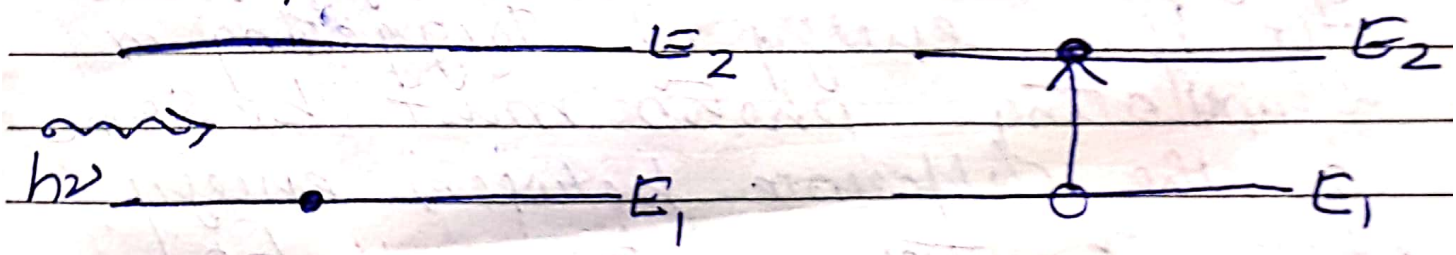
LASER :- Light Amplification by Stimulated Emission of Radiation.

Characteristics of a LASER :-

1) They are highly coherent. ie is same phase
2) They are highly Intense
3) They are highly Directional
4) They are highly Monochromatic ie have only one wavelength.

Principle of Laser :-

Absorption :-



When radiation of suitable frequency fall on atomic system, an electron absorbs the energy and jump to higher energy level. This process is called absorption.

$$h\nu = E_2 - E_1$$

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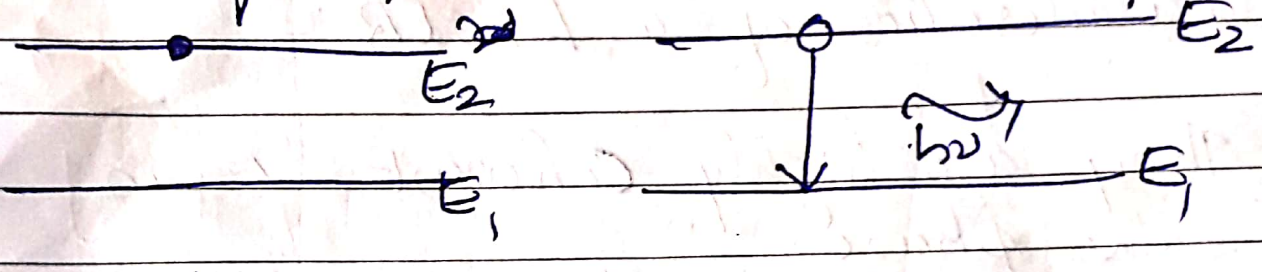
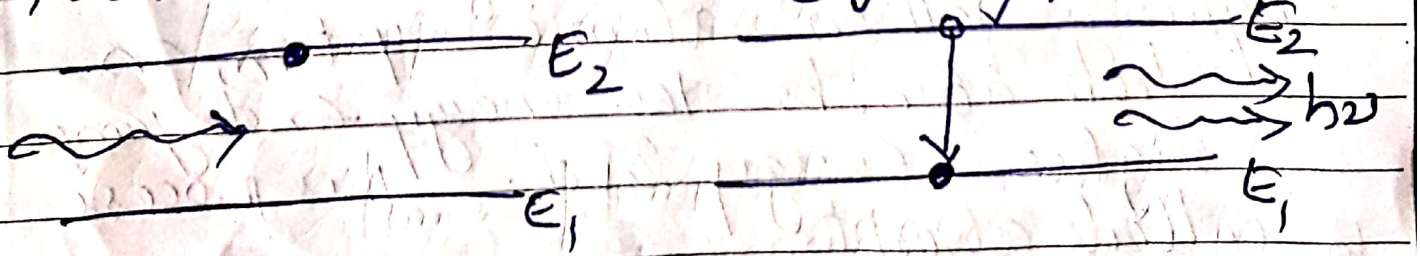
ii) Spontaneous Emission :- The atom in the excited state is not stable. So it returns to lower energy state by emitting a photon.



This is spontaneous emission. The light obtained will be uncontrolled and incoherent.

iii) Stimulated Emission :- An incident photon of energy $h\nu$ stimulates the transition of electron from higher energy state to lower energy state. For this, energy of triggering or stimulating photon must be same as the difference between energy states. Emitted photon will be identical with the triggering photon.



Metastable State :-

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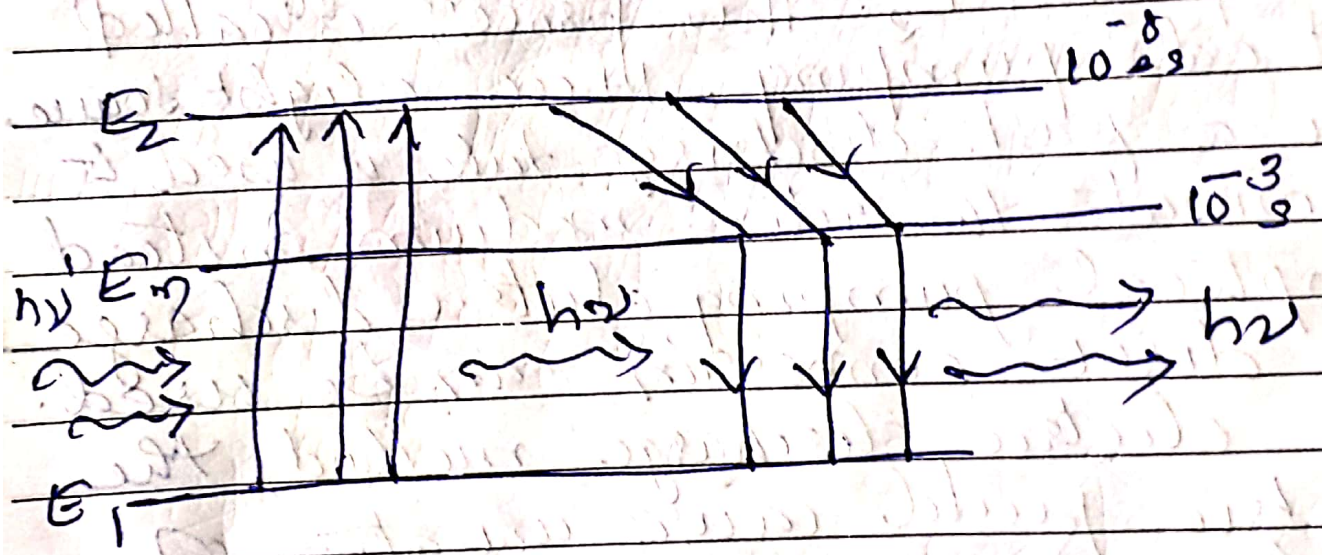
When an atom is in excited state it can reside only for a time of about 10^{-8} s. In certain crystals like ruby, there is an intermediate energy state E_m between levels E_1 and E_2. So electrons jump from E_2 to metastable state E_m and stay there for about 10^{-3} s. Then they with return to ground state.



Population Inversion :-

- Electrons absorb energy $h\nu = E_2 - E_1$ and get excited to E_2. Since life time in E_2 is 10^{-8} s they decay to metastable state of E_m which has a life time of 10^{-3} s. So after some time population of es in E_m becomes greater.

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than population in E_1. This is known as population inversion.

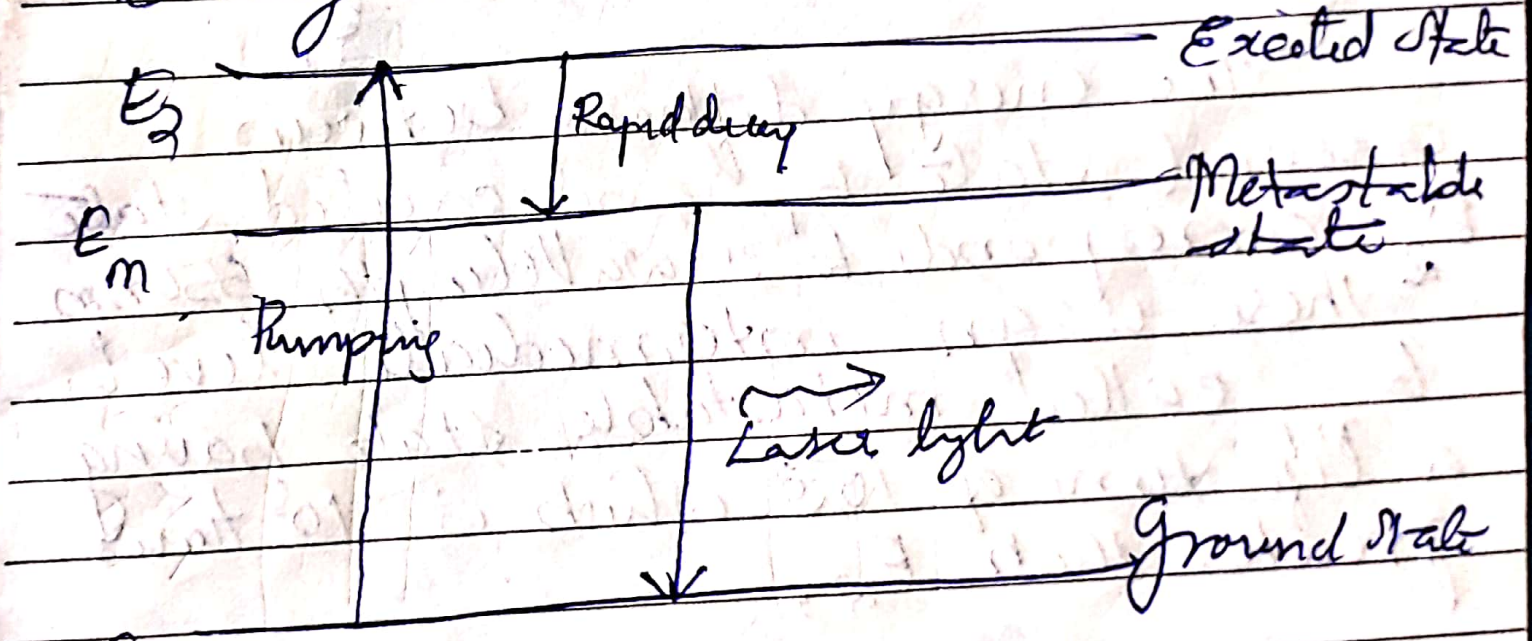
Optical pumping :-

Inorder to achieve population inversion, electrons must be pumped to excited state. For this, light must be supplied initially which match with the energy difference of E_1 and E_2. This process is called optical pumping. Here a light source like a flash discharge tube is used to illuminate the active medium. Instead of optical pumping electric discharge or direct conversion can be used. In electric discharge method, the electric field causes ionisation of medium. In direct conversion, electric energy is converted to light energy

Principle of Lasing Action :-

Atoms from the ground state E_1 are pumped up to an excited state E_2 by optical pumping.

From E_2, atoms decay rapidly to a ~~intermediate~~ of energy E_m which is meta-stable. Thus after some time, E_m will become heavily populated than E_1 attaining population inversion. This is the ~~state~~. When ions in metastable state are exposed to light, they ~~de~~ decay to ground state emiting strong coherent laser beam.



Ruby Laser :-

Principle

Ruby rod is a crystal of Aluminium oxide (Al_2O_3) doped with 0.05% of chromium oxide (Cr_2O_3). Cr^{3+} ions causes lasing action.

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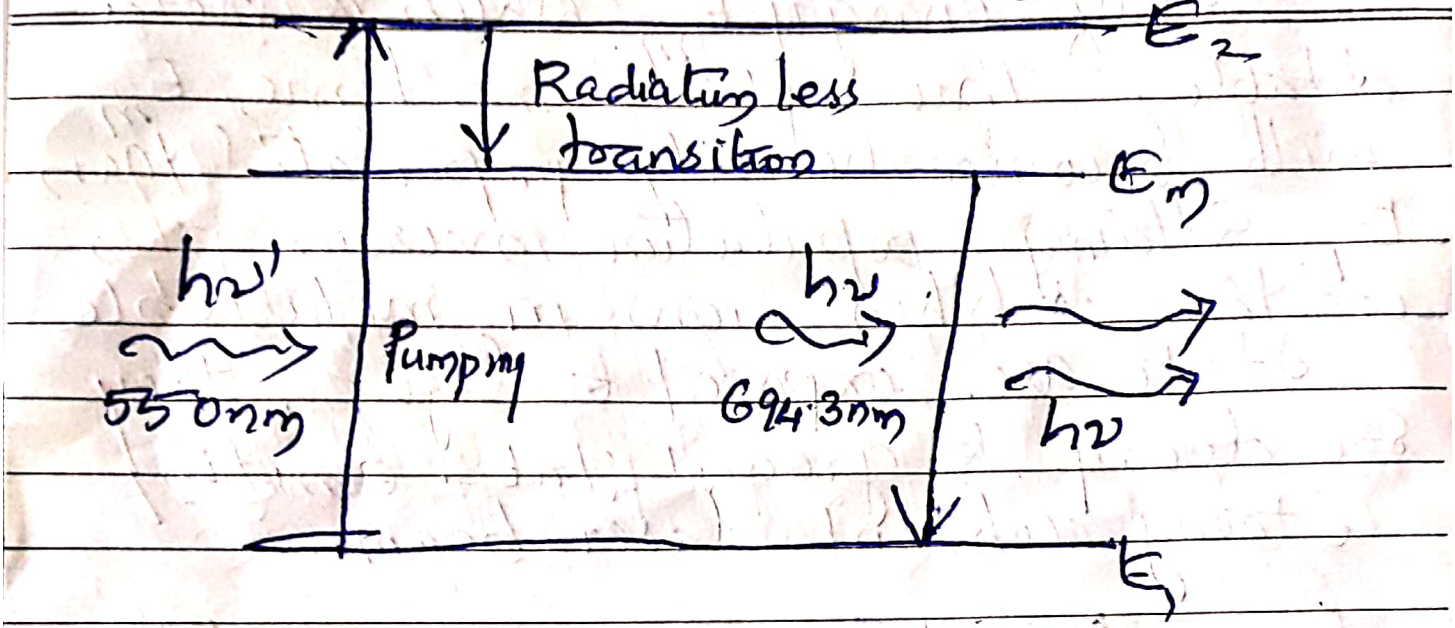

The energy difference between ground state E_1 and excited state E_2 corresponds to a wavelength 550nm. There is an intermediate level E_m called metastable state having a life time of 10^{-3} which is 10^5 times greater than E_2.

Optical pumping results when incident photons of wavelength 550nm ~~from~~ raises Cr^{3+} ions from E_1 to E_2. E_2 decay to E_m without radiation loss. Since E_m has longer life population inversion occurs. When these ions are exposed to red light of wavelength 694.3nm, stimulated emission occurs. This results in laser ~~one~~ emission.

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Construction

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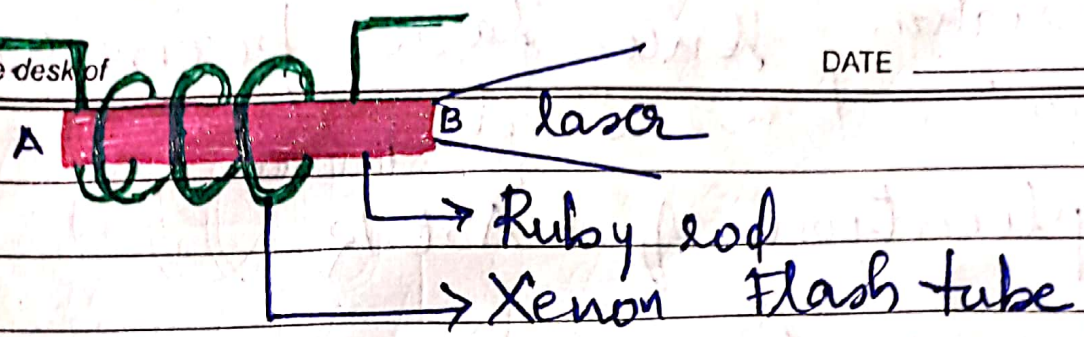

It consists of a pink Ruby rod of length 4cm. Its ends are optically plane and parallel. End A is fully silvered and B is partially silvered. The rod is surrounded by a flash tube (Xenon) in the form of a spiral.

Working :- When a flash of Xenon light takes place Green and yellow lights are absorbed by chromium ions and get excited to E_2. Red light is allowed to pass through. Excited atoms jump to a metastable state and population inversion is achieved. The energy difference $E_m - E_2$ is same as the energy of red radiation already present. Hence the red light travelling to and fro between silvered ends

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Causes stimulated emission of red radiation. Hence laser beam are produced as short pulses.

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Applications of LASER

1) In optical communication
2) Measurement of large distances
3) Space explorations
4) Welding
5) Hole drilling
6) Surgery
7) Thermonuclear fusion
8) Military applications
9) Holography