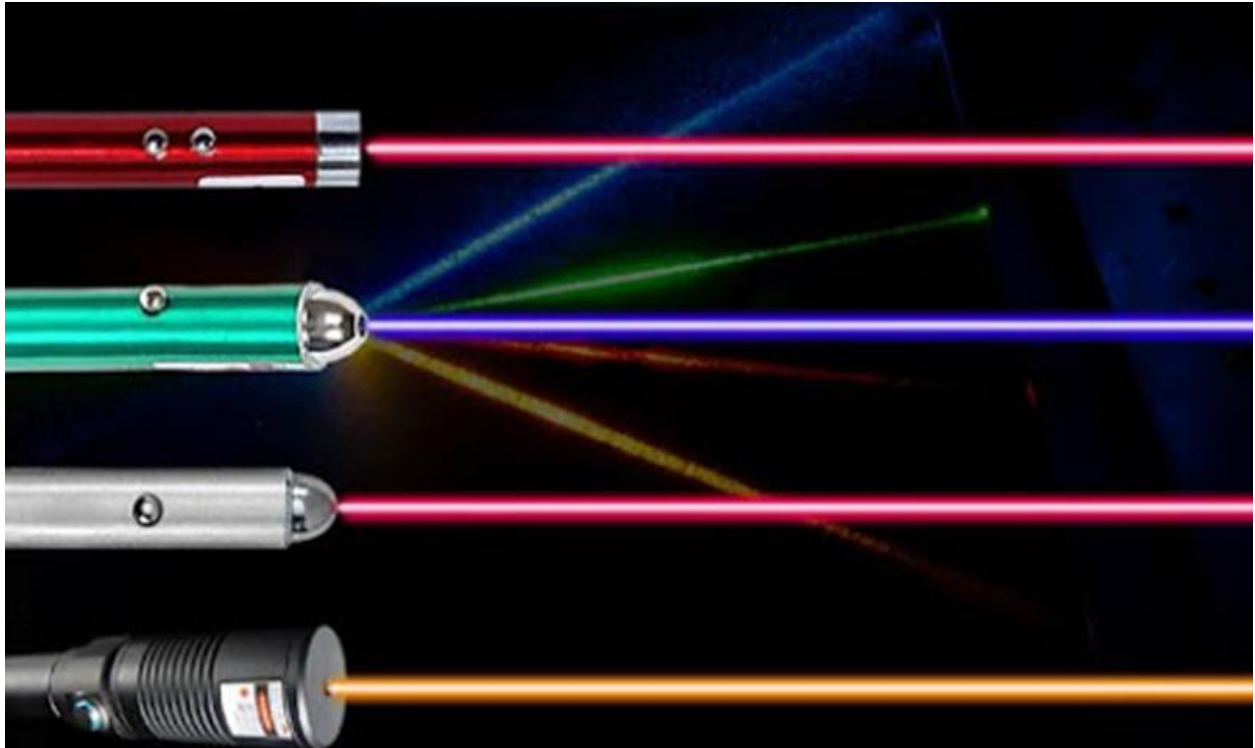


LASER

Light amplification by stimulated emission of radiation. The stimulated emission is used for amplifying light wave.



Characteristics of Laser light:-

- Laser light is coherent source.
- Laser light is highly mono chromatic.
- A laser beam is highly directional.
- Laser can produced a light in a very narrow wavelength beam.

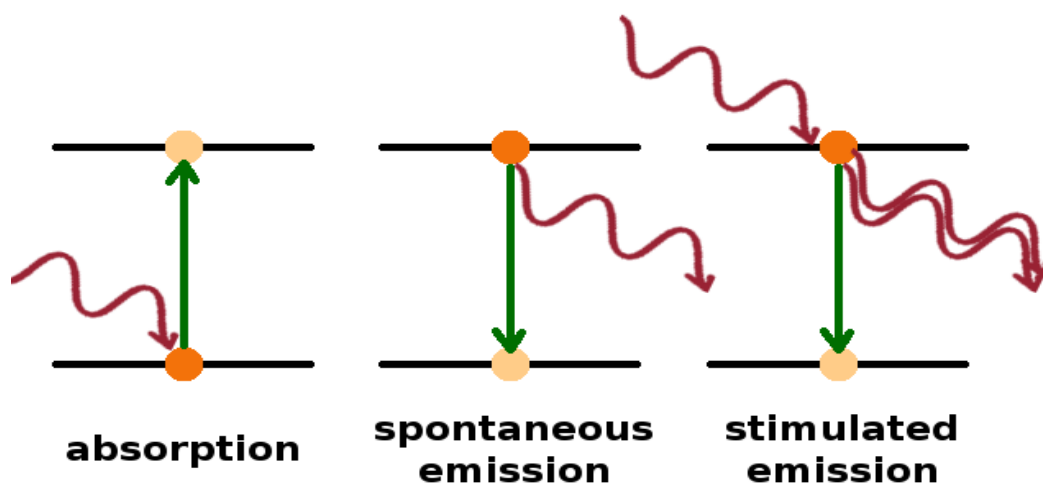
- The laser light has brightness compare to an ordinary light. Due to its high intensity it can also be used for welding, cutting and drilling.

Spontaneous emission:-

An atom cannot stay in the excite state for a longer time. In a time of about 10^{-8} second the atom returns to the lower energy state by releasing a photon of energy $E_2 - E_1 = hf$. The emission of a photon by an atom without any external impetus is called spontaneous emission.

Stimulated emission:-

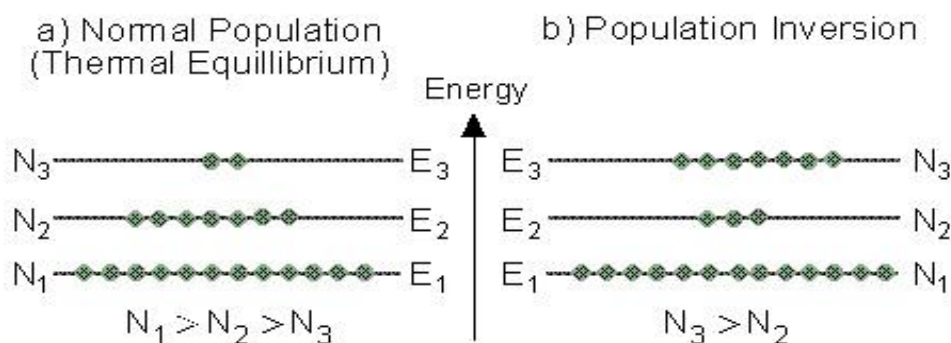
The atom in the excited state can be returned to original state before spontaneous emission by the incident of an external photon with the emission of both incident and stimulated photon. This type of emission of radiation is called the stimulated emission or induced emission.



Optical pumping and population inversion:-

To achieve a high percentage of stimulated emission, a majority of atoms should be at the higher energy level than lower level. The establishment of situation in which the number of atoms in the higher energy level is greater than that of lower energy level is called population inversion.

The process carried out to achieve population inversion by supplying energy to laser medium is called pumping. When the pumping is done by light energy it is called optical pumping.



Meta-stable state:-

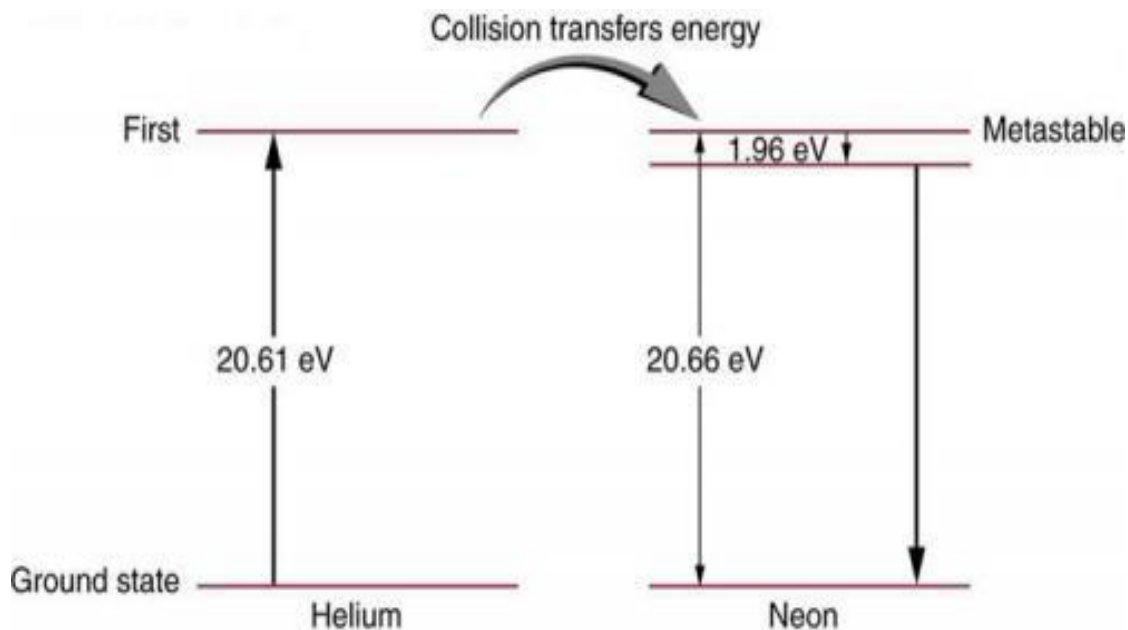
Normally the life time of an atom in excited state is very short (10^{-8} sec). However the atoms of special elements can stay for longer time in the higher energy state where the life time is greater than 10^{-4} sec. Such higher state is called meta-stable state.

Active medium:-

Atoms are generally characterized by a large no of energy levels. However all types of are not suitable for laser operation.

Even in a medium consisting of different species of atoms, only a small fraction of atoms of a particular type have energy level suitable for achieving population inversion such atoms can produce more stimulated emission than spontaneous emission and causes amplification of light. These atoms are called active centers. The rest of the medium acts as host and supports active center. The medium hosting the active center is called active medium.

He-Ne Laser:-



The He-Ne laser consists of a long and narrow discharge tube. The lasing material is the mixture of gases with a concentration of about 15% He and 85% Neon. The electrodes in the discharge tube are connected to a high voltage source of few KV DC. So an electric discharge takes place within the gas. With this high

voltage some of the helium atoms are rise to a meta-stable state $E_1 = 20.61\text{eV}$ above the ground state as shown in figure. It so happens that Ne atoms has a meta-stable state at nearly the same energy $E_3 = 20.66\text{eV}$. The helium atoms do not quickly return to the ground state by spontaneous emission rather it transfer the energy to neon atom during collision.

With such collision the energy of excited helium atoms will be transfer and it drops to ground state, however getting excess energy neon atoms is excited to the state E_3 . The kinetic energy of the helium atom provides the additional 0.05 eV required for excitation of neon atoms. In this way the higher state E_3 of neon becomes the meta-stable state. Hence, the lasing action takes place by stimulated emission between E_3 and E_2 states of neon. The laser light emitted is 632.8nm .

Uses of Laser:-

- Laser light is used to investigate the basic laws of interaction of atoms and molecule with electromagnetic wave. (Scientific uses)
- It is used for distance measurement.
- It can be used in different communication system.
- It can be used in wars to target missiles.
- It is highly intense. Therefore it can be used in drilling, welding, and cutting of material.

- Laser light is used in eye surgery, treatment of dental decay, destruction of tumor and for treatment of skin diseases. (Medical uses)
- It can be used in scientific research. Such as in the study of chemical and crystalline structure of various molecule, in Raman spectroscopy, in astronomy.
- Laser light is used for automatic control for rockets and satellite. It can also be used for detection and destroy of aero planes, missiles and tanks.
- It can be used in laser induced fusion process, isotopes separation and to measure the optical depth.

Exercise:-

1. Differentiate between spontaneous and stimulated emission of radiation. Explain the construction and working of He-Ne laser with a suitable energy diagram.
2. What is population inversion? Explain why laser action cannot occur without population inversion between atomic levels?
3. What are active medium, population inversion and optical pumping? Give the importance in the study of laser. Write a method for getting He-Ne laser.
4. Explain the term stimulated emission, population inversion, optical pumping and meta-stable state. Explain working principles of He-Ne laser.
5. Differentiate between LASER and ordinary light.