APPLIED SCIENCE (PHYSICS)

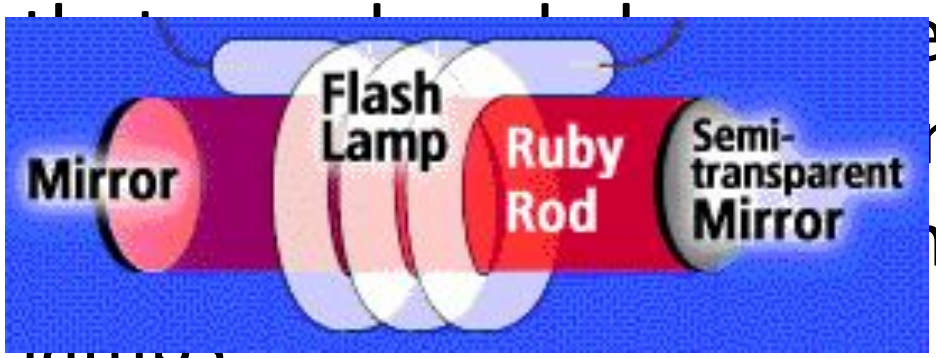
LASER

OBJECTIVES

- To understand the acronym of Laser.
- To study properties of laser.
- To understand spontaneous and stimulated emission.
- To understand Population inversion & optical pumping.
- To study He-Ne laser: Principle, construction & working.
- To study Laser pointer.
- To study engineering applications of Laser.

LASER

- LASER stands for Light Amplification by Stimulated Emission of Radiation.
- Laser light is coherent, monochromatic, unidirectional and extreme intense.
- The light emitted by lasers is different from



common light

ndesce s,

high-in rc

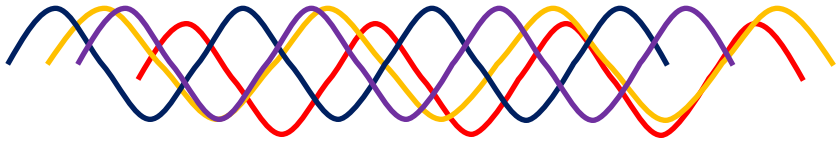
LASER PROPERTIES

Ordinary light source

many colours

all direction

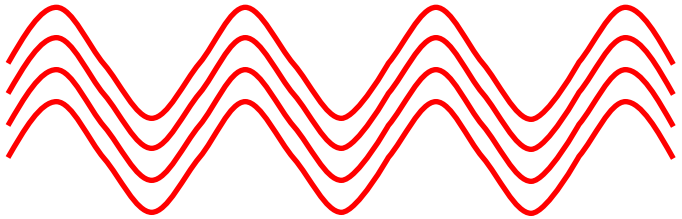
wavelength not in phase



single colour

one direction

wavelength in phase

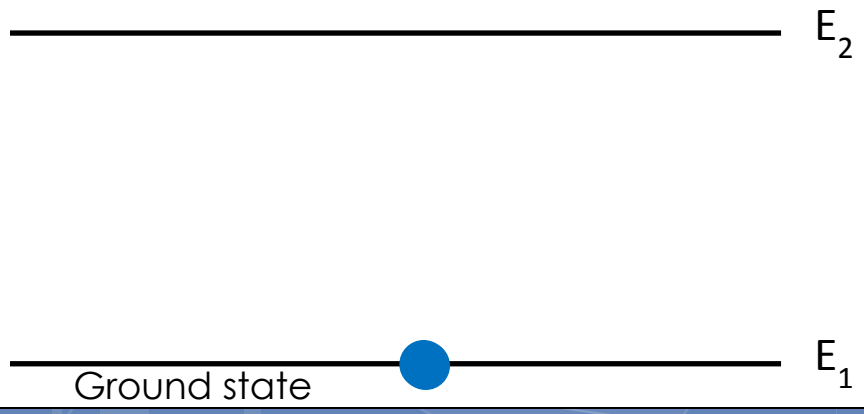


LASER PROPERTIES

- The light emitted from a laser is monochromatic (one colour/wavelength), in contrast ordinary light is combination of many colours of light.
- Lasers emit light that is unidirectional (narrow beam with sharp focus) whereas ordinary light, is emitted in many directions away from the source.
- The light from a laser is coherent (wavelength in phase), in case of ordinary light are of mixture of many wavelengths.
- The laser light are extremely intense and create more brightness at a particular spot than ordinary light.

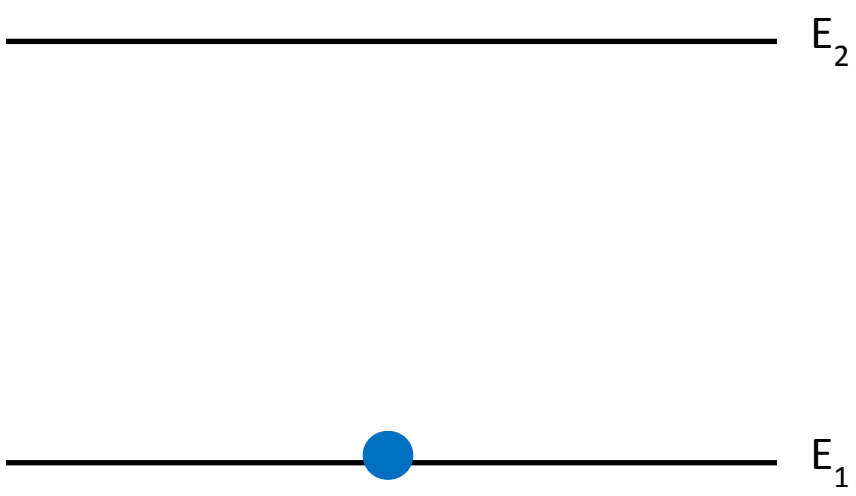
STIMULATED ABSORPTION

- When a photon of energy $h\upsilon = E_2 - E_1$ is incident on an atom then the atom moves from lower energy level E_1 to higher energy level E_2.
- Here, the atom in the ground state absorbs energy of incident photon and gets stimulated towards higher energy level E_2, this process is called as **stimulated absorption**.



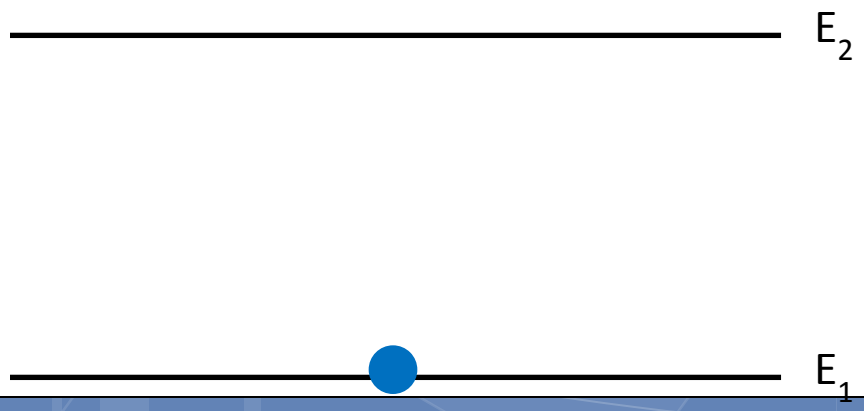
SPONTEANOUS EMISSION

- After completion of life time of the atom, the excited atom comes to ground state spontaneously by emitting a photon of energy hυ, this is known as spontaneous emission.



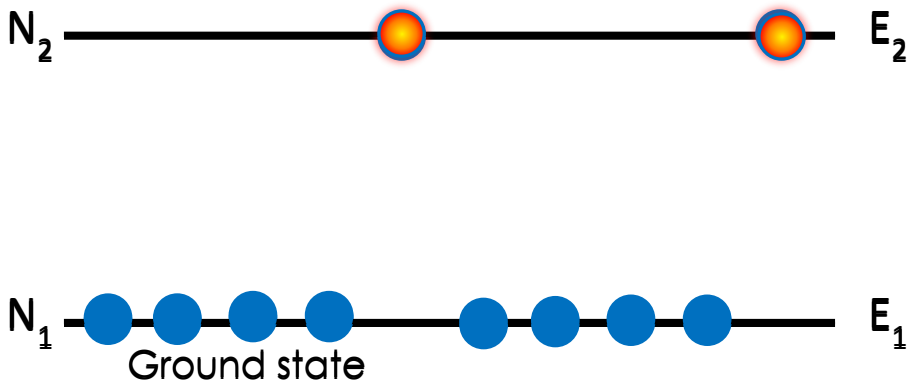
STIMULATED EMISSION

- When the atom is in excited state is triggered by an incident photon.
- The atom in excited state make a transition to ground state by emitting another photon which is identical to incident photon.
- This process of forced emission of photons due to incident photon is called as **stimulated emission**.



POPULATION INVERSION

- Usually population of lower energy level is high and that of higher energy level is low $N_1 >>> N_2$.
- In order to produce stimulated emission, population of higher excited state should be greater than that of low energy state. i.e. $N_2 >>> N_1$.
- The process of raising the atoms from lower energy state to higher excited energy state is called as **pumping**.

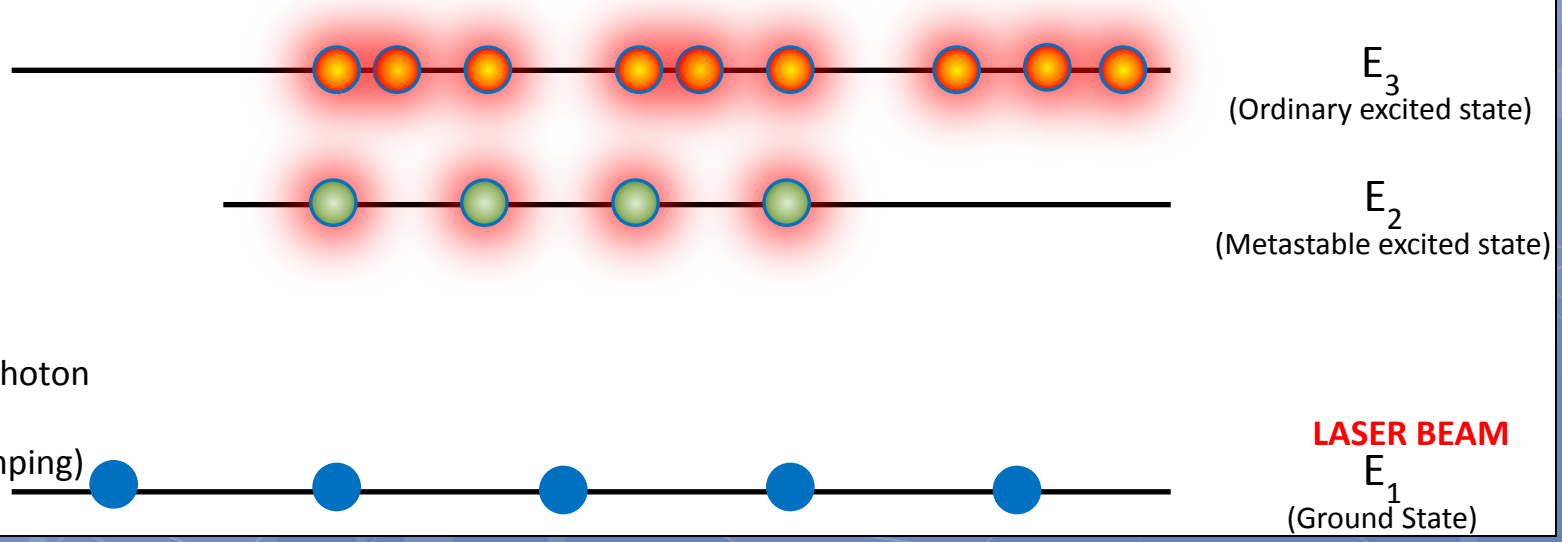


STATES OF ENERGY

- **METASTABLE STATE**
  - An excited state in which life time is greater than 10^{-8} sec.
- **ORDINARY EXCITED STATE**
  - Atom remains in excited state for life time of 10^{-8} second and then comes to ground state immediately.
- **METASTABLE EXCITED STATE**
  - Atom relaxes in excited state for longer life time 10^{-3} and then comes to ground state.

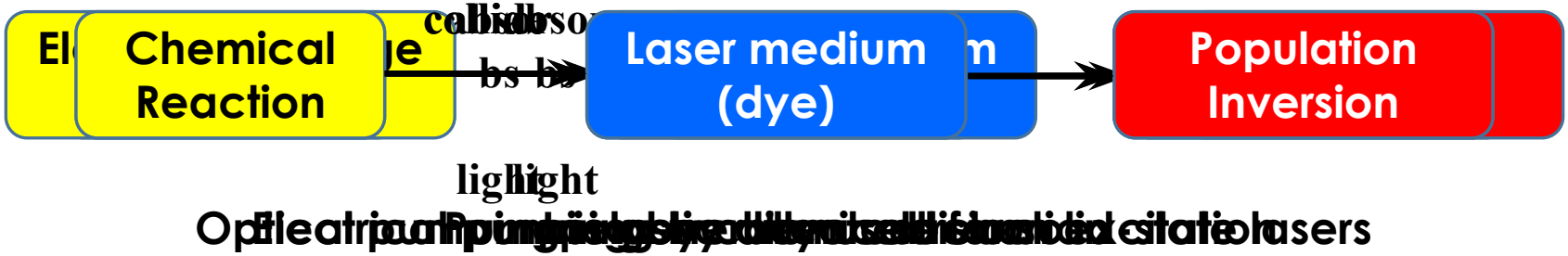
THREE LEVEL ENERGY

- [illegible] with incident photon in same direction.

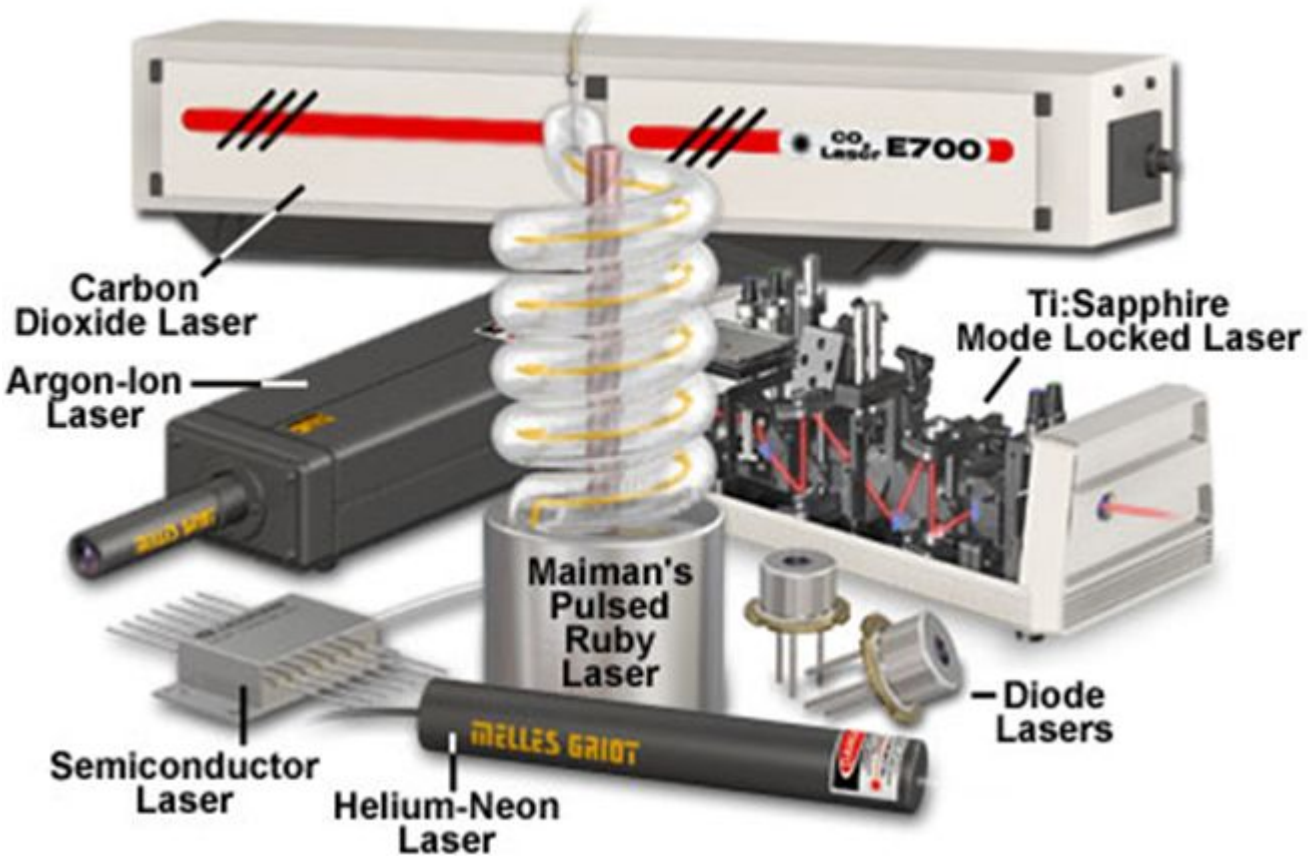


PUMPING

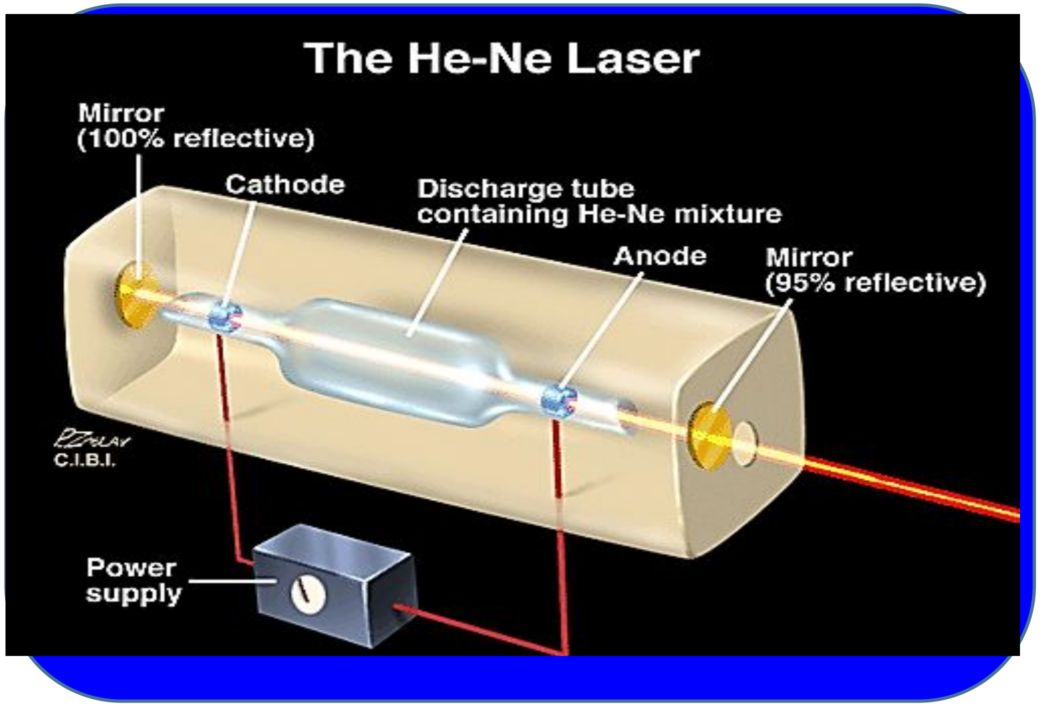
- The process of raising the atoms from lower energy state to higher excited energy state is called as pumping.
- The process of raising the atoms from lower energy state to higher energy state using light medium is called as optical pumping.



Common Laser System



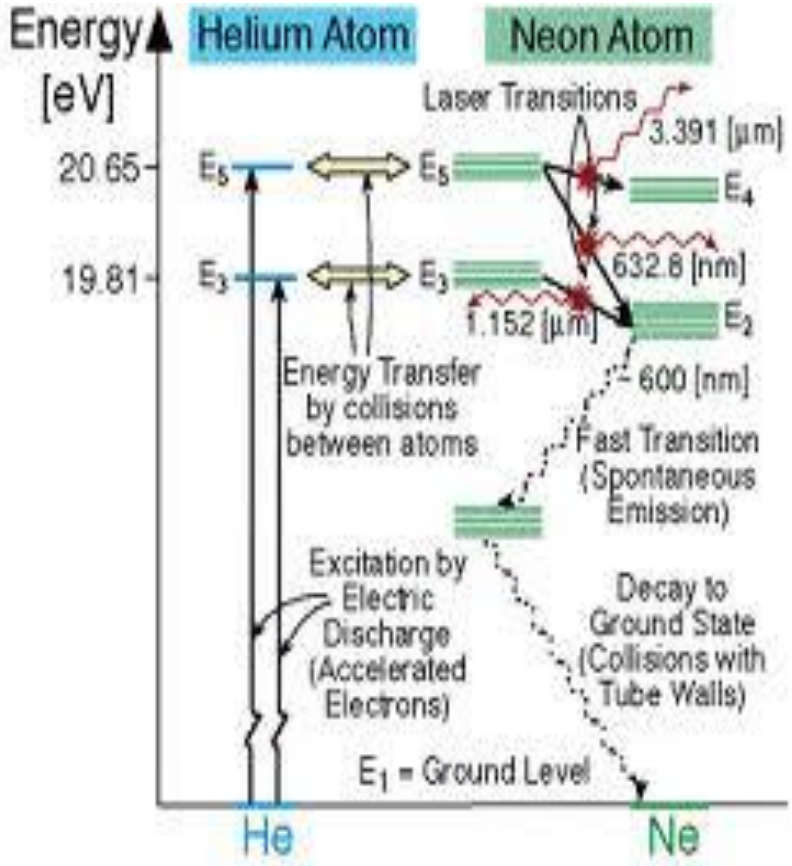
He-Ne GAS LASER



- … to a population inversion.

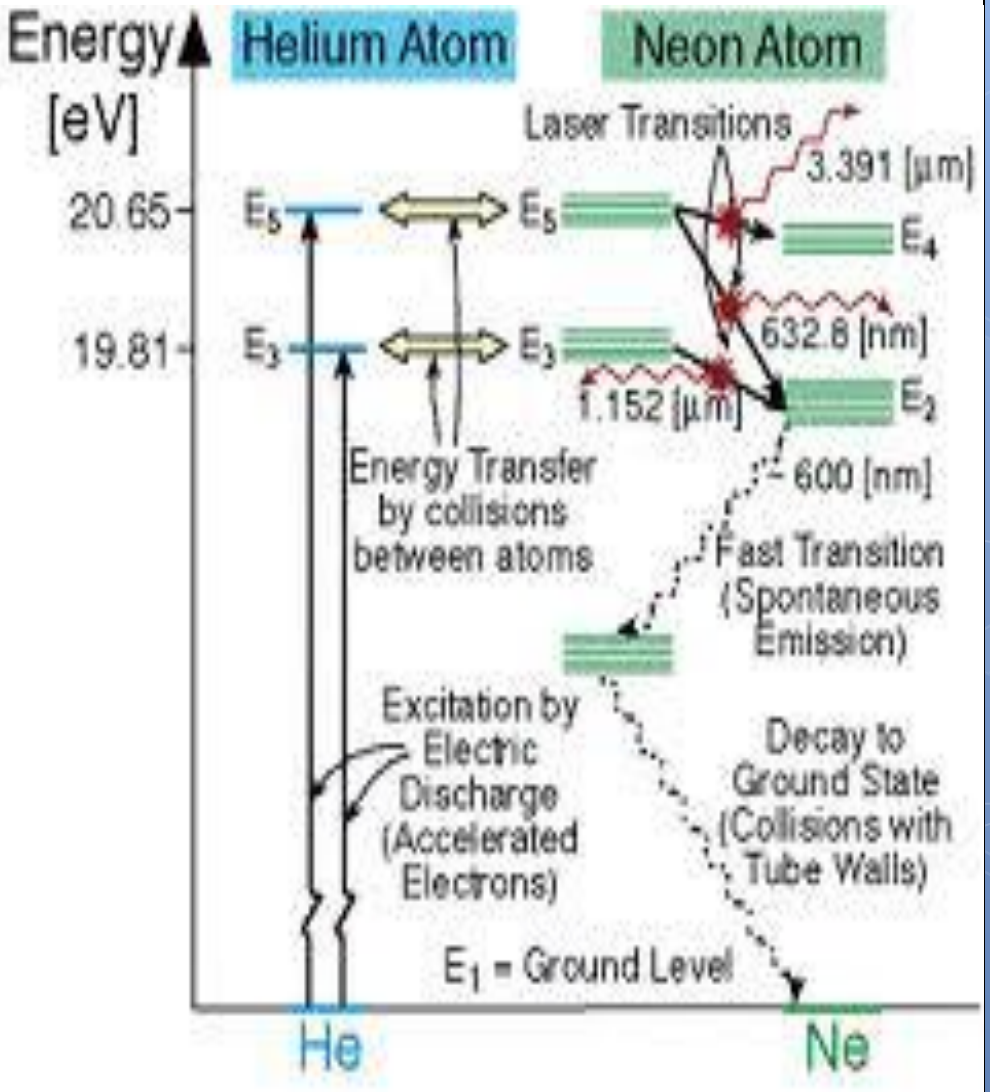
Working

- An electric discharge is produced in the gas by voltage provided by an external source.
- Collisions with the electrons from the discharge excite He and Ne atoms to metastable states respectively at 20.61 eV and 20.66 eV.



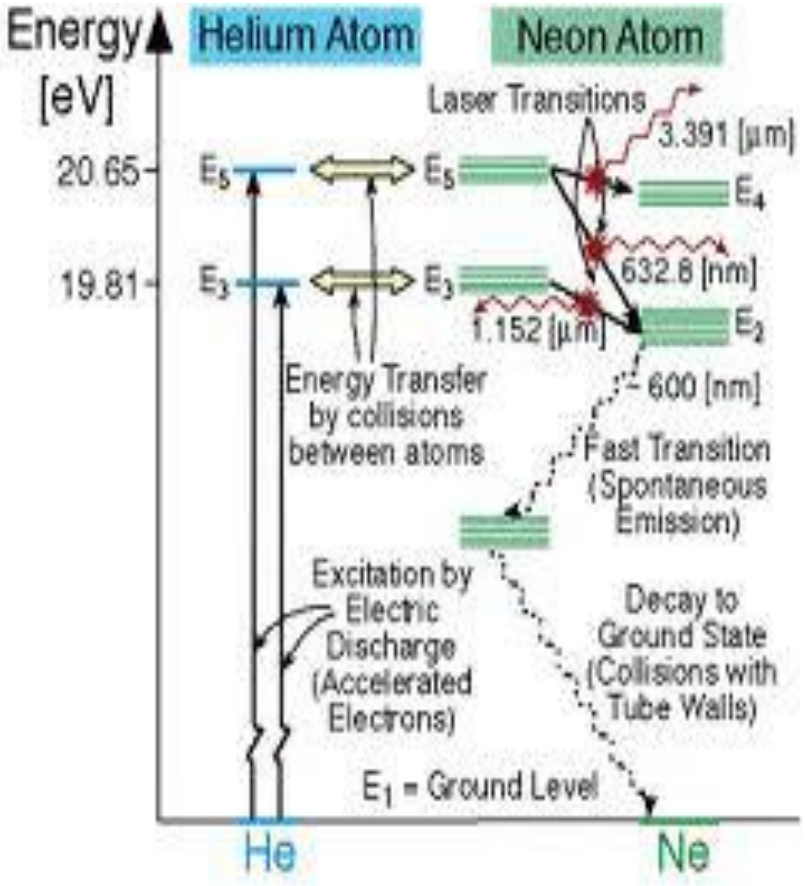
Working

- As the Ne higher energy levels E4 and E6 are closed to excited energy levels H2 and H3 of He.
- At this levels, energy is transferred to He atoms due to collisions with Ne atoms.
- Thus population inversion is done by He atoms.



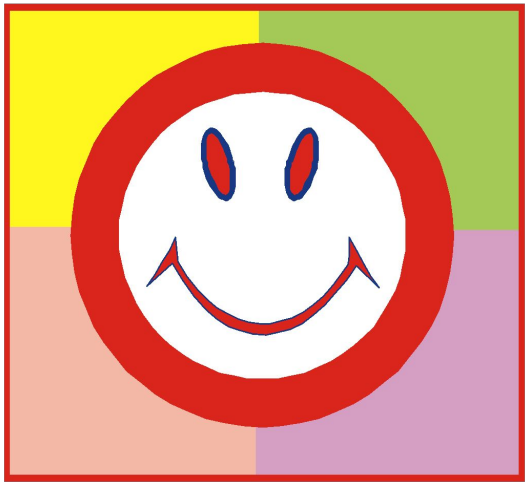
Working

- Actual lasing is done by Ne atoms.
- The Laser transition in Ne is from metastable state at 20.66 eV to an excited state at 18.7 eV.
- This laser beam is used to read the bar codes.



APPLICATION

- Used to read barcodes in shopping malls, supermarkets, library, etc.
- Used in cutting, drilling and welding metals.
- Used in eye surgery, cosmetic surgery, dental surgery and also to destroy kidney stones and cancer cells.
- Used in holography and printers.
- Used to measure distance between planets.



Thank you