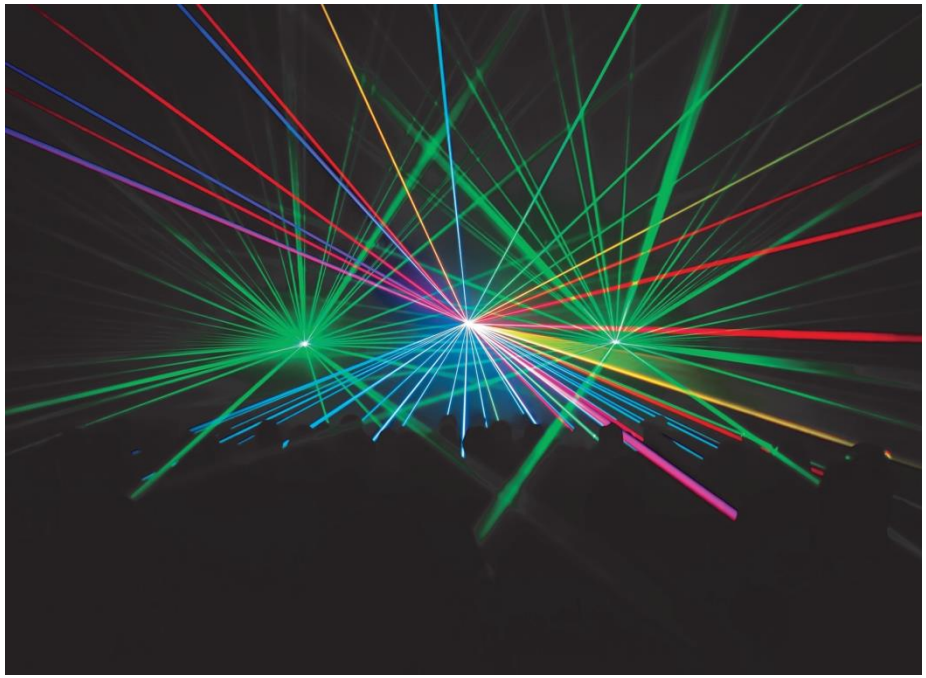
UNIT-IV

Laser, Holography and Optical Fibre

Lecture-3: Laser



Content of Lecture

- HELIUM–NEON LASER , CONSTRUCTION AND WORKING
- APPLICATIONS OF LASER
- LASER IS USED IN OPTICAL FIBER COMMUNICATION
- LASER BEAM WEILDING
- LASER CUTTING
- LASER DRILLING
- LASER WELDING
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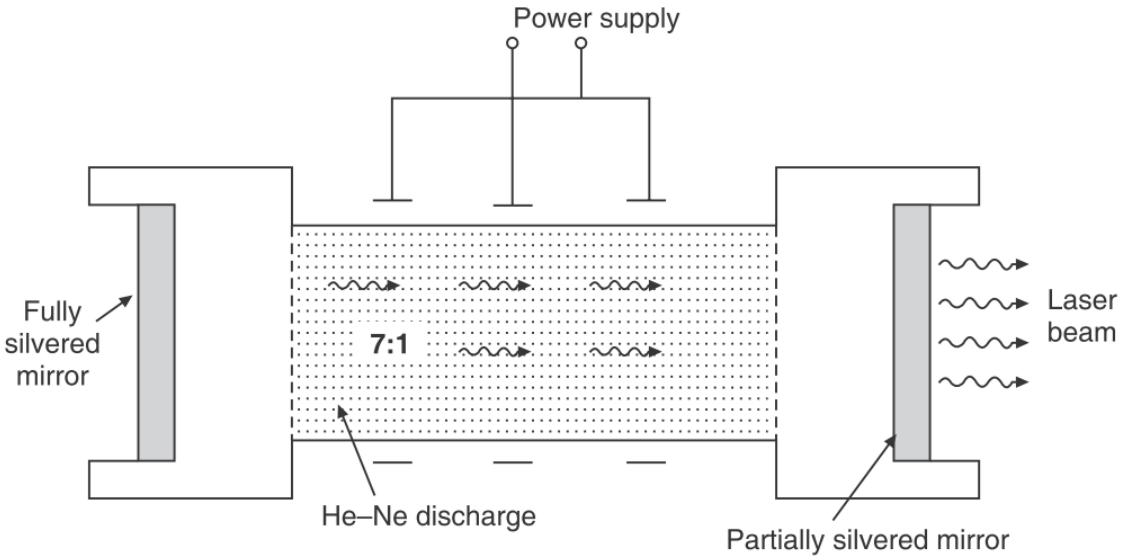
- APPLICATION EXAMPLES

HELIUM–NEON LASER

❖Helium–neon laser is a four-level gas laser. In this laser, population inversion is achieved by electric discharge.

Construction

❖A mixture of about 7 : 1 of He and Ne at the pressure of about 1 mm of mercury is used as active material in this laser.



HELIUM–NEON LASER

Construction

❖The mixture of these gases in suitable ratio is filled in a glass tube at the pressure of 1 mm of mercury.

❖At both ends of the tube, there are optically plane and parallel mirrors, out of which one is fully silvered mirror and other is partially silvered mirror.

❖An electric discharge is produced in the gas mixture by electrodes connected to a high-frequency electric source.

❖The spacing between the mirrors is equal to an integral multiple of half wavelengths of the laser light.

Working

❖An electric discharge is produced in the gas mixture by electrodes connected to a high-frequency electric source.

❖ Due to this electric discharge, He and Ne atoms get excited to reach metastable state at 20.61 eV and 20.66 eV, respectively.

❖Some of the He atoms (excited) transfer their energy through collision to Ne atoms (unexcited) at the ground state.

❖ Actually, the transfer of energy between any two atoms is possible only when the required energy for the excitation of one atom is exactly equal to the energy possessed by the other atom.

Working

❖But here, the Ne atoms require an energy of 20.66 eV for excitation while the excited He atoms have only 20.61 eV; the difference of energy, i.e., 0.05 eV is being provided to He atoms by the kinetic energy of He atoms.

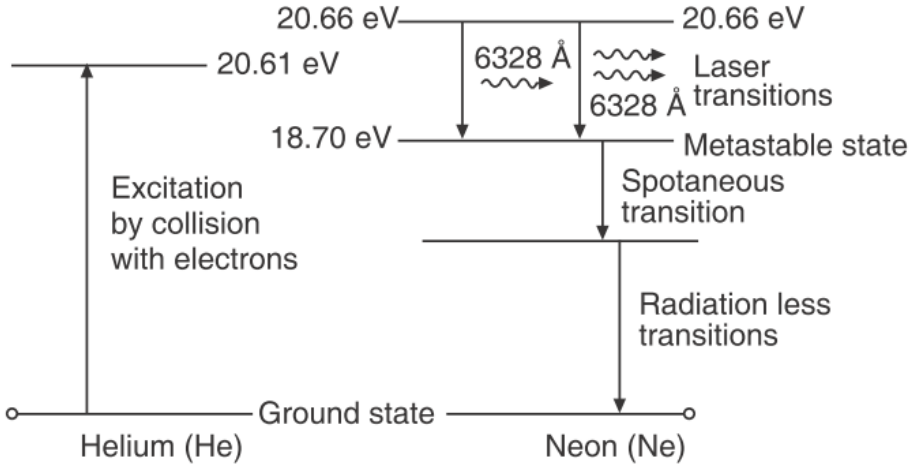
❖Now, the He atoms have the required energy to raise the Ne atoms to their metastable state.

❖ Thus, the only purpose of having He atoms in the He–Ne laser is to help the population inversion in the Ne atoms.

❖The excitation process of helium and neon atoms with their different transitions is shown in Figure.

TRANSITIONS

- The excited neon atom passes spontaneously from 20.66 eV to 18.70 eV which emits a photon of 6328 Å.
- This photon stimulates another excited atom which leads to laser transition.
- Atoms from the 18.70 eV level, the Ne atom passes down spontaneously to a lower metastable state emitting incoherent light and finally goes to the ground state with radiationless transition.
- Since the laser transition does not terminate at the ground state, thus, the power needed for excitation is less than that in a three-level laser.



APPLICATIONS OF LASER

- Laser Is Used In Optical Fiber Communication
- It is frequently used in the cutting and welding of metallic rods.
- It is used to vaporize unwanted material during manufacturing of electronic circuits and chips.
- These are used for different important purposes in medical, defense, industries, research and development organizations.
- Laser is frequently used in CD players, laser printers, laser copiers, etc.
- It is used for specific task in thermonuclear reactions.
- Laser is used for separating various isotopes.
- Laser is used in holography.

APPLICATIONS OF LASER

LASER BEAM WEILDING

- It is a welding technique used to join multiple pieces of metal through the use of a laser.
- The beam provides a concentrated heat source, allowing for narrow, deep welds and high welding rates.
- The process is frequently used in high-volume applications such as in the automotive industry.
- Laser beam welding has high power density (of the order of 1 MW/cm^2) resulting in small heat-affected zones, and high heating and cooling rates.
- The spot size of the laser can vary between 0.2 mm and 13 mm.

LASER BEAM WEILDING

- The speed of welding is proportional to the amount of power supplied but also depends on the type and thickness of the work pieces.
- LBW is a versatile process, capable of welding carbon steels, HSLA steels, stainless steel, aluminum, and titanium.
- LBW is particularly dominant in the automotive industry.
- A derivative of LBW, laser-hybrid welding, combines the laser of LBW with an arc welding method such as gas metal arc welding (GMAW).

LASER CUTTING

- It is a technology that uses a laser to cut materials and is typically used for industrial manufacturing applications.
- Laser cutting works by directing the output of a high-power laser, by computer, at the material to be cut.
- The material then either melts, burns, vaporizes away, or is blown away by a jet of gas, leaving an edge with a high-quality surface finish.
- Industrial laser cutters are used to cut flat sheet material & structural and piping materials. Advantages of laser cutting over mechanical cutting include easier work holding and reduced contamination of work-piece and high precision.
- A disadvantage of laser cutting is the high energy required.

LASER DRILLING

- Laser drilling is a successful manufacturing solution in many industries. Advantages include non-contact processing, low-heat input into the material, flexibility to drill a wide range of materials, accuracy, and consistency.

- The other benefits associated are drilling submicron holes and small holes with large aspect ratios, and drilling at angles.

- The common techniques used in drilling are ***percussion hole drilling*** and ***trepanning.***

- ***Percussion drilling*** is a process where multiple pulses are applied per hole to achieve the desired results. High-speed on-the-fly drilling is a percussion type drilling process often used in drilling filter and guide vanes.

LASER WELDING

- ***Trepanning*** is a process cutting large holes or contouring shaped holes. The advantages of trepanning include large holes, consistency, and ability to drill shaped holes. Trepanning also reduces the hole taper.

- Fiber lasers can be focused to spot sizes as small as 10–20 mm. The Q-switch fiber laser offer very good drilling capabilities in thin sheets, ceramics, and silicon.

- High-power fiber lasers are used for rock drilling applications and for oil and gas exploration industries. The high peak and energy/pulse are also used for drilling thick metals.

Application Examples

- Drilling of flow filters and strainers
- Submicron drilling in flexography ceramic rolls
- High-speed drilling of guide vanes
- Hole drilling of silicon
- Drilling diamonds for removing imperfections
- On-the-fly-cooling holes and Rock drilling

Assignment Based on this Lecture

- Describe the construction and working of Helium–Neon laser.
- Mention the Important Applications of laser
- Describe Laser beam welding, Laser cutting, Laser drilling, Laser welding
- Mention the application examples of LASER.