

Chapter – 5 : LASERS

He – Ne and Ruby Laser Systems

Q. 1: Explain construction and working of He - Ne gas laser.

Ans.:

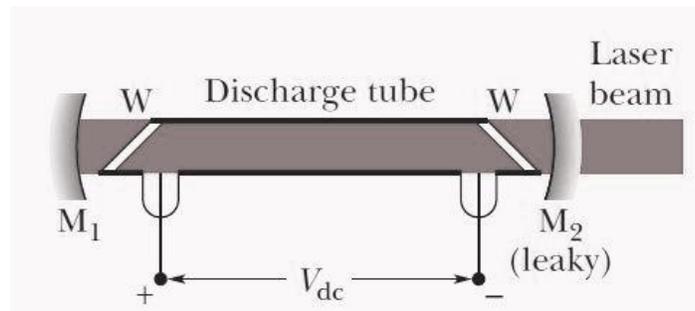


Fig.-1

Construction:

Above figure -1 shows the construction of Helium – Neon gas laser. A mixture of Helium and Neon gas is filled inside the discharge tube in a proportion of 20:80 at low pressure (Helium at a pressure of 1mm of Hg and Neon at 0.1mm of Hg). Pumping is done by a dc electrical discharge in a discharge tube. When discharge occurs Helium and Neon atoms excite to their various excited states. There are two mirrors M_1 and M_2 , among them the mirror M_1 is totally reflecting and mirror M_2 is partially leaky. Both these mirrors are placed perpendicular to the tube axis. We get a continuous laser beam of wavelength 632.8 nm through mirror M_2 from this laser system.

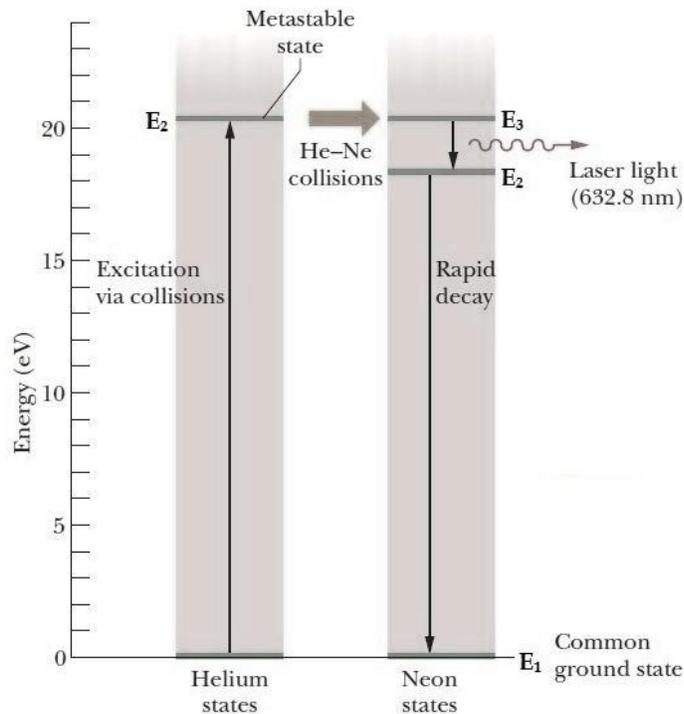


Fig.-2

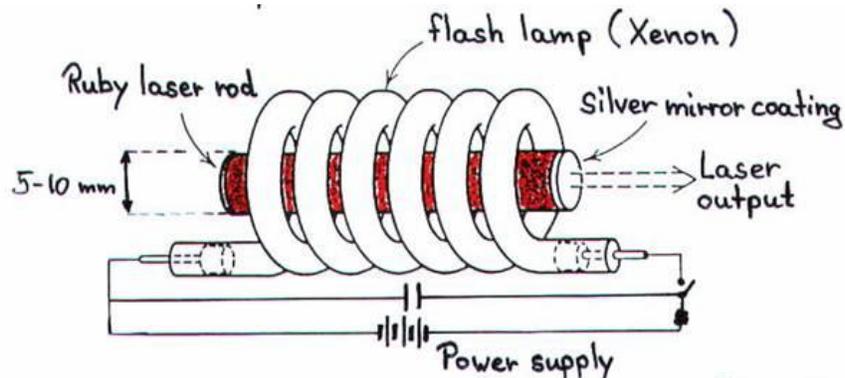
Working:

Above figure – 2 shows the simplified energy level diagram for Helium and Neon atoms. When discharge occurs through the discharge tube, electrons collide with Helium atoms and make them to move to an excited state E_2 . Now, energy of E_2 state of Helium is 20.61 eV and energy of E_3 state of Neon is 20.66 eV. So, when these E_2 state Helium atoms collide with ground state Neon atoms, Helium atoms give their energy to ground state Neon atoms and Neon atoms get excited to an excited state E_3 . This collision is possible because of the metastability of E_2 state of Helium. During this collision ground state Neon atom gets 20.61 eV of energy directly from excited Helium atom, but this energy is not enough to move ground state Neon atom to an excited state E_3 of energy 20.66 eV. Neon atom still requires 0.05 eV of energy to reach E_3 state. Neon atom gets this small amount of energy from the kinetic energy of excited Helium atom during collision and gets excited to E_3 state. E_2 state of Neon is mostly unoccupied and thus population inversion is achieved between E_3 and E_2 states of Neon. When initially Neon atoms move from E_3 state to E_2 state spontaneously, they emit photons of wavelength 632.8 nm in all directions. To produce laser, only a single photon of this wavelength, moving parallel to the tube axis, is required, which then by a chain reaction of stimulated emission process between two mirrors M_1 and M_2

multiplied to produce a continuous laser beam of wavelength 632.8 nm. This continuous laser beam is obtained through mirror M_2 .

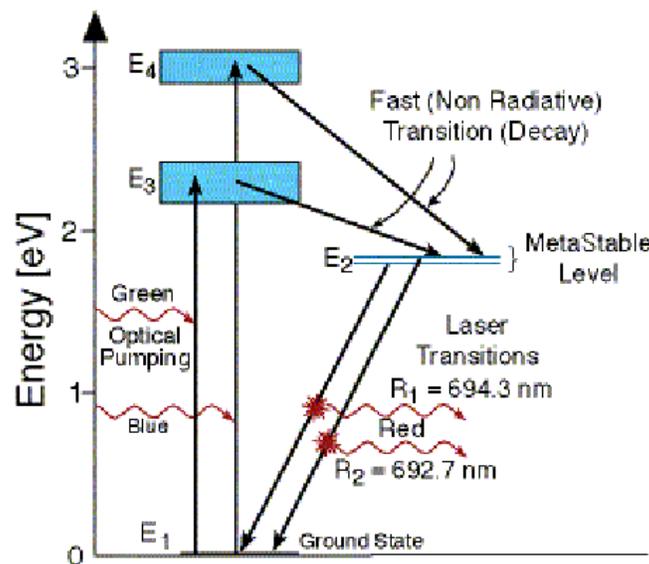
Q. 2: Explain construction and working of Ruby laser.

Ans.:



Construction:

In this laser system a synthetic ruby rod is used as an active medium. A crystal of Aluminum Oxide (Al_2O_3) is doped with Cr^{3+} ions. Doping amount of Cr^{3+} ions is ranging from 0.05 % to 0.5 % and they take place of Al atoms in Al_2O_3 crystal. The ruby rod is illuminated by an intense light flash from a helical xenon discharge lamp as shown in figure. The ends of ruby rod are highly polished and silvered which act as two mirrors M_1 and M_2 . Mirror M_1 is totally reflecting and M_2 is partially leaky and they are perpendicular to the rod axis. Laser pulses are obtained through mirror M_2 .



Working:

When the flash lamp is switched on, an intense flash of light occurs. Absorption of photons (of wavelength 550 nm and 400 nm specially) from this light flash excites many of the Cr^{3+} ions to the energy bands denoted by E_3 and E_4 . After some time, they transit from these energy bands to a pair of metastable states denoted by E_2 . These transitions of Cr^{3+} ions from E_4 and E_3 states to E_2 state are non-radiative transitions and energy is released in the form of heat energy to the crystal. Due to the metastability of the state E_2 , population inversion is achieved between this E_2 state and ground state of Cr^{3+} ions. When initially Cr^{3+} ions move from E_2 state to ground state spontaneously, they emit photons of energy (E_2-E_1) in all directions. Only a single photon of energy (E_2-E_1) , moving parallel to the rod axis is needed to produce laser. This photon will then be multiplied by chain reactions of stimulated emissions between two mirrors M_1 and M_2 . Ruby laser is a three level laser system and the laser obtained from this laser system is in the form of pulses of light of wavelength 694.3 nm, because three level laser system requires a huge amount of pumping energy every time to create population inversion.

References:

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