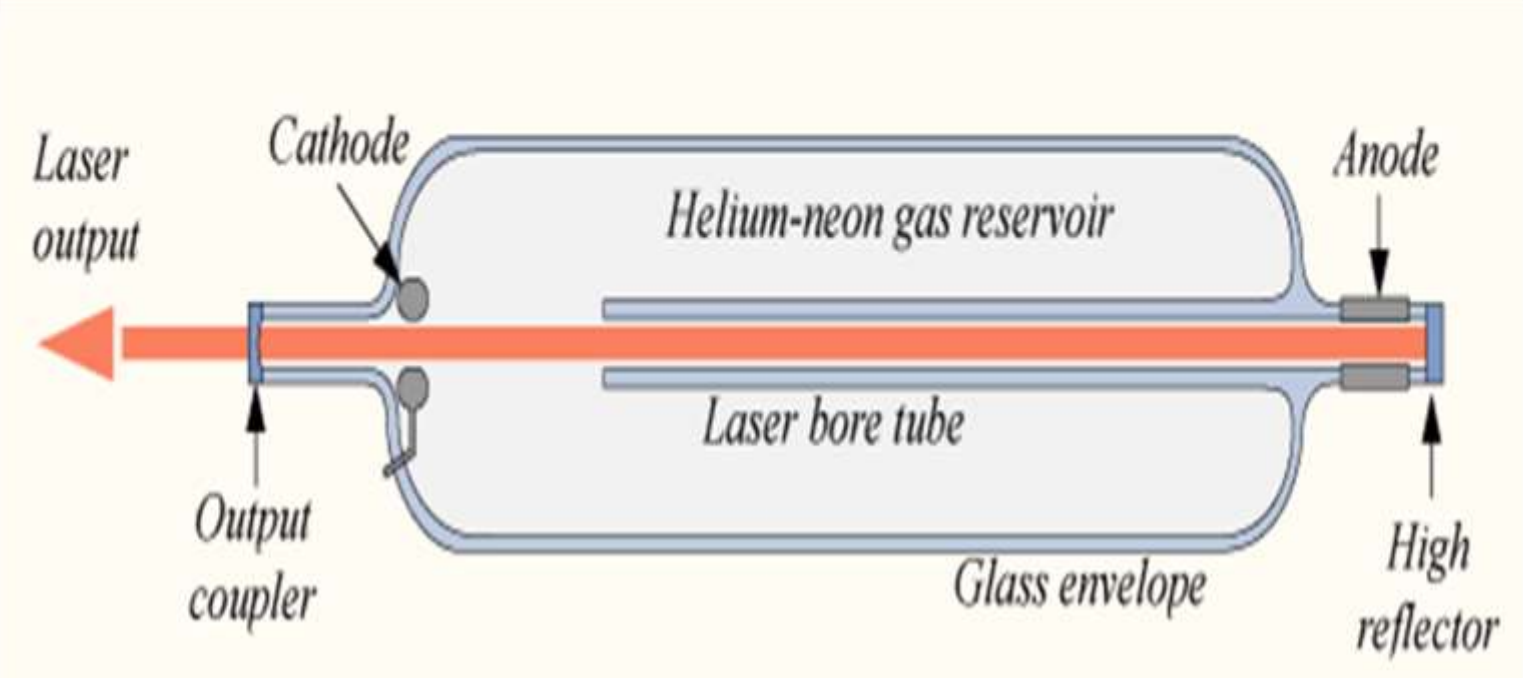
Helium-Neon Laser

- This was the first gas laser to be operated successfully.
- It was invented by **Ali Javan and his co-workers** at Bell Telephone Laboratories in the USA in 1961
- Its usual operation wavelength is **6328Å** in the red portion of the visible spectrum.
- He-Ne laser is a four-level laser.

Construction of He-Ne laser

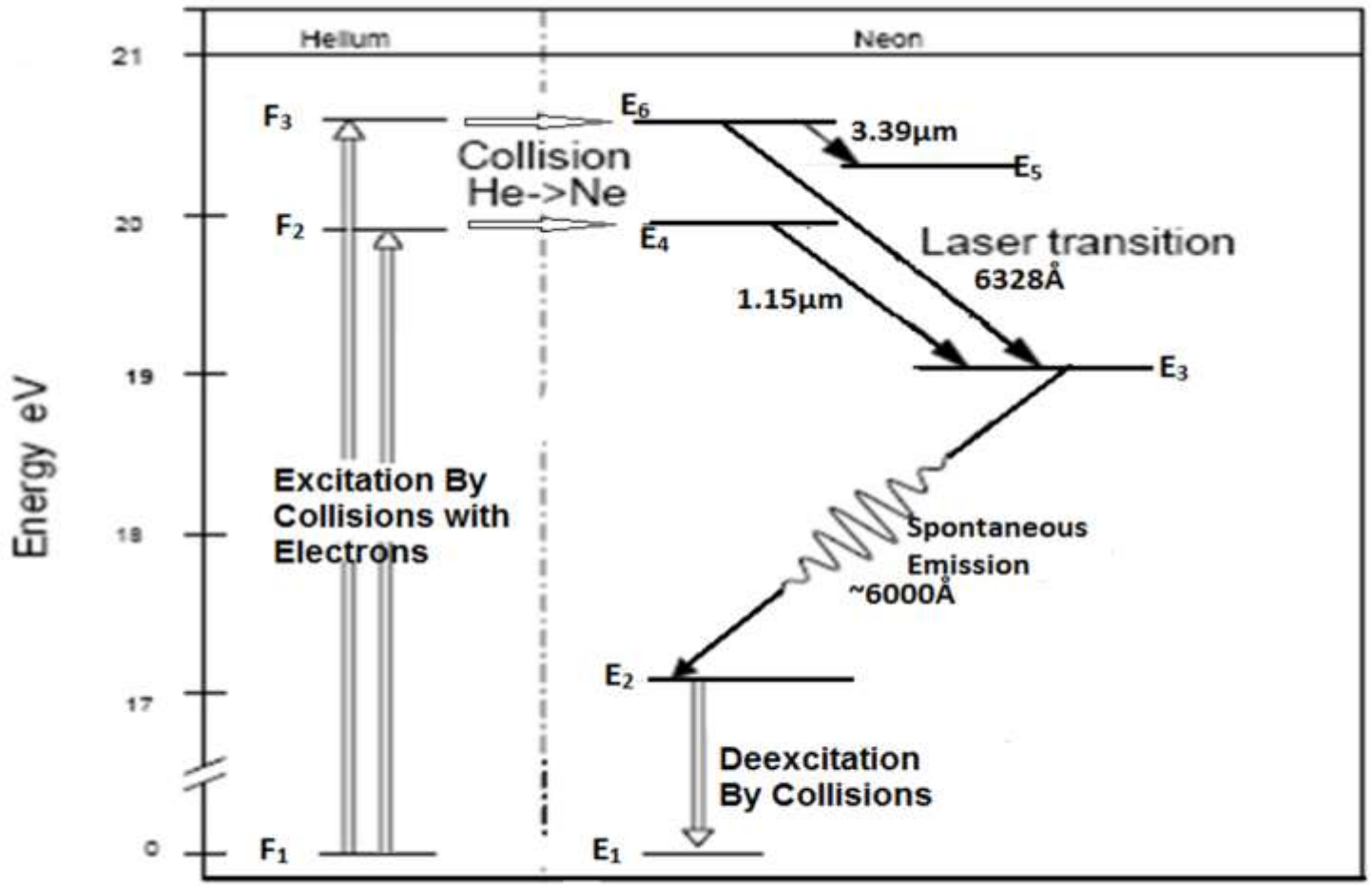
- This consists of a mixture of helium and neon gases in a ratio of about 10:1
- The setup consists of a long and narrow discharge tube of length 80 cm and diameter of 1 cm.
- The pressure inside the tube is about 1mm of Hg.
- The energy or pump source of the laser is provided by an electrical discharge of around 1000 volts through an anode and cathode at each end of the glass tube. A current of 5 to 100 mA is typical for CW operation.
- The optical cavity of the laser typically consists of a plane, high-reflecting mirror at one end of the laser tube, and a partially transparent mirror of approximately 1% transmission at the other end.

Schematic diagram of a Helium-Neon Laser



Working of He-Ne Laser:

- Electric discharge is passed through the gas. As electrons have a smaller mass than ions, they acquire a higher velocity.
- The He atoms are more readily excitable than Neon as they are in higher concentration.
- The role of He atoms is to assist in pumping Ne atoms to higher energy levels via interatomic collisions
- Electrons collides with the He atoms, excite them to the metastable states F_2(19.81eV) and F_3(20.61eV) stay for a sufficiently long time.
- The excited He atoms losses energy through collision with unexcited Ne atoms, Ne atoms are excited to the metastable states E_4(18.7eV) & E_6(20.66eV) which have nearly the same energy as the levels of F_2 & F_3 of He.



Relevant Energy Levels of Helium and Neon Laser

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- The probability of energy transfer from He atoms to Neon atoms is more as there are 10 He atoms to 1Neon atoms in the medium
- Population inversion is achieved between E_6 & E_5, E_6 &E_3, E_4 &E_3.
- $E_6 \rightarrow E_3$ transition generates a laser beam of red colour of wavelength 6328Å
- $E_4 \rightarrow E_3$ transition produces laser beam of wavelength 1.15μm (not in visible region)
- $E_6 \rightarrow E_5$ transition results in a laser beam of 3.39μm (not in visible region)

Contd..

- $E_3 \rightarrow E_2$ transition generates incoherent light due to spontaneous emission (~6000Å)

- From the level E_2, the Ne atoms are brought back to the ground state through collisions with the walls

- Also since E_2 level is a metastable state, it can decrease the population inversion by exciting atoms from E_2 to E_3. Hence the tube is made narrow so that Ne atoms in level E_2 de-excite by collision with the walls of the tube.

- By a proper design of resonator, laser action in Ne is obtained in the visible region (**6328Å**)

Applications of He-Ne laser

The main advantage of gas lasers is that they can be operated continuously. The gas lasers show exceptionally high monachromaticity and high stability of frequency. The output of the laser can be tuned to a certain available wavelength. Hence, the gas lasers are widely used in industries.

- The Narrow red beam of He-Ne laser is used in supermarkets to read bar codes.
- The He- Ne Laser is used in Holography in producing the 3D images of objects.
- He-Ne lasers have many industrial and scientific uses, and are often used in laboratory demonstrations of optics.

Reference Books:

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2. B. B. Laud Lasers and Nonlinear optics (2ndEdn.). New Delhi: New Age international (P) Limited.

3. L. Allen, Essentials of Lasers. Oxford: Pergamon Press.