

Helium Neon Laser

lecture 4

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Helium-Neon laser

Helium-Neon Laser is the first gas Laser developed by Ali Javan and his co-workers in 1961.

Helium-neon lasers are the most popular continuous wave (CW) laser. It is a four level laser. The first He-Ne laser emitted infrared at $1.15 \mu\text{m}$.

Later on a number of Neon transitions were investigated to achieve population inversion and it was found that the 632.8 nm line has highest gain in visible region of the spectrum.

Construction of Helium-neon laser :

The helium-neon laser is a long narrow discharge tube which is made of quartz glass.

It consists of three essential components:

- i. Pump source (high voltage power supply)
- ii. Gain medium (laser glass tube or discharge glass tube)
- iii. Resonating cavity

Pump source:

In Helium Neon Gas laser a high voltage dc power supply of about 2 to 4 KV is used as pumping source. This high voltage source supplies dc current of 3 to 20 mA through the gas mixture of helium and Neon.

Gain medium:

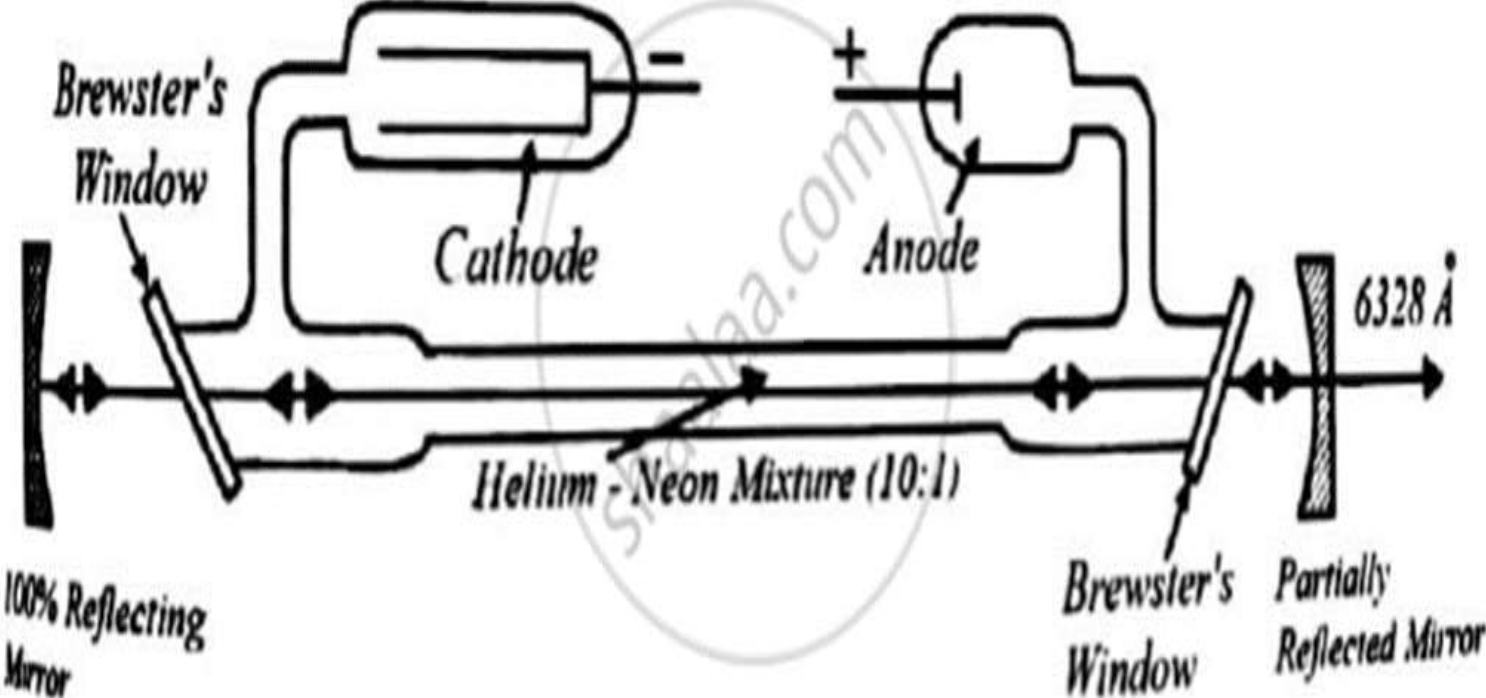
In this laser helium and neon gas is mixed in a ratio 10:1 and is used as a gain medium. The mixture of helium and neon gas contained in glass tube so that the partial pressure of helium is 1 mbar whereas that of neon is 0.1 mbar.

The end windows of the tube are made optically flat and set at Brewster's angle to make the output light polarised.

Resonating system:

The resonating system of the He Ne laser consists of two concave mirrors, one fully reflector and other partial reflector. The fully silvered mirror will completely reflect the light whereas the partially silvered mirror will reflect most part of the light but allows some part of the light to produce the laser beam.

Experimental arrangement of He NE laser



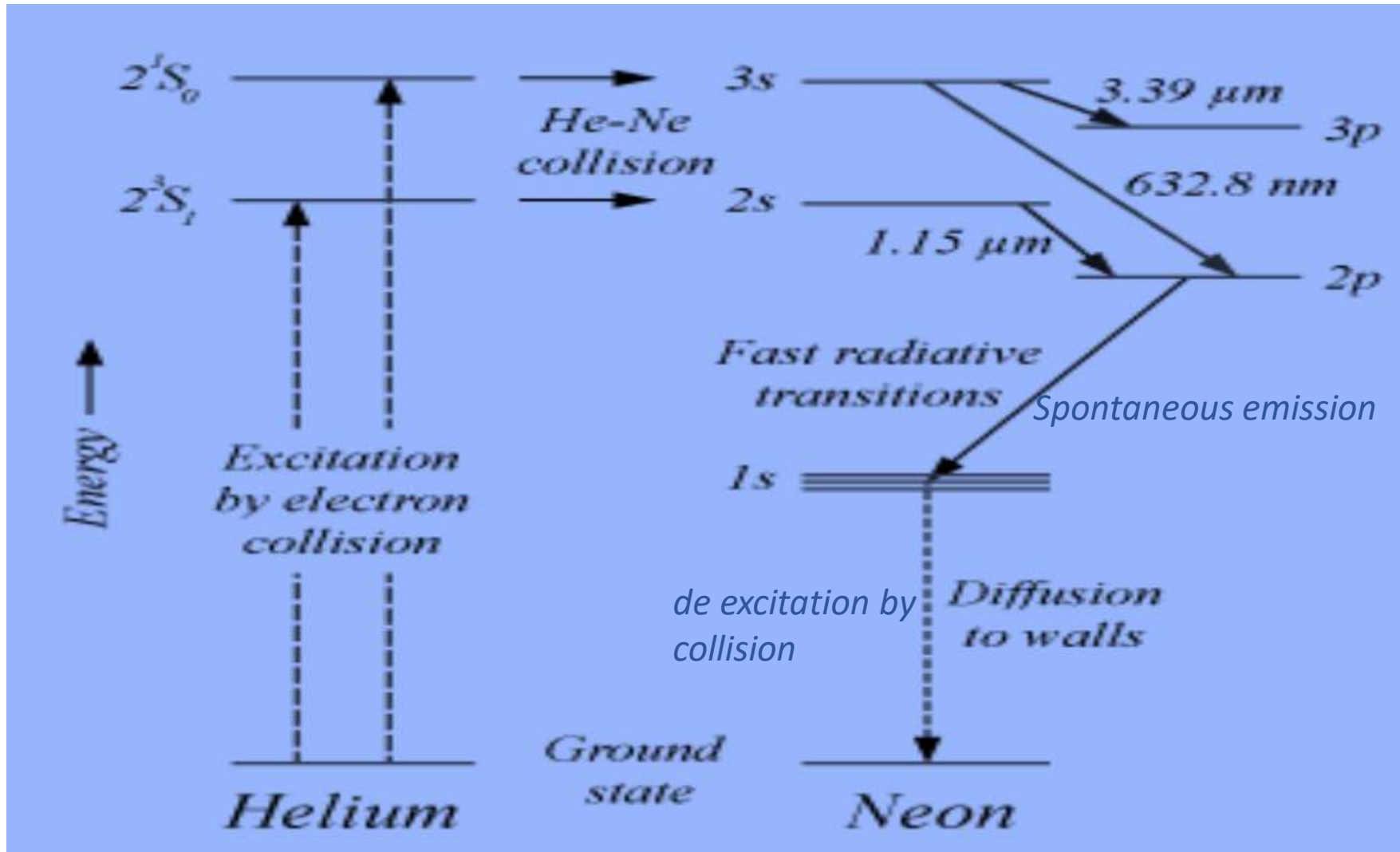
Working of He Ne laser:

When current flows through the gas, the energetic electrons transfer some of their energy to the helium atoms.

As a result, the helium atoms in the ground state gain enough energy and jump to the excited states 2^1s of energy 20.16 and 2^3s level of energy 19.81 eV which is a close approximate to the energy of metastable states of Neon.

After that He atoms transferred their energy to the Ne atoms which are at ground state and excite them to the metastable states $3s$ and $2s$ and helium atoms come down to the ground state. This process is repeated so it is called as resonant energy transfer mode.

Energy level diagram of He and Ne for lasing action



Since 3s and 2s are metastable states for neon atoms, so it quickly attain population inversion. After some period, the metastable states electrons of the neon atoms will spontaneously fall into the next lower energy states by releasing photons. This is called spontaneous emission. Random photons emitted spontaneously set stimulated emission and coherent radiation is produced.

For transition of the neon atoms from upper 3s to 2p level generates radiation of wavelength $3.39\ \mu\text{m}$ and 2s to 2p generates wavelength of $6328\ \text{\AA}$. Also the transition from 2s to 2p gives wavelength of $1.15\ \mu\text{m}$.

Since waves with wavelength $3.39\mu m$ and $1.15\mu m$ are weak they are absorbed by the quartz glass tube and we get only light with wavelength 6328 \AA .

From 2p to 1s level the atom comes down spontaneously and the atoms come back to ground state from the state 1s by the process of de-excitation by collision.

Since the two end of He Ne tube are at Brewster's angle so its cuts the perpendicular components of unpolarised laser light and we get polarised light of wavelength 6328 \AA as output.

Advantages of helium-neon laser:

Helium-neon laser emits laser light in the visible portion of the spectrum.

Low cost

Operates without damage at higher temperatures

Disadvantages of helium-neon laser:

It has Low efficiency and low gain

Helium-neon lasers are limited to low power tasks.

Applications of helium-neon lasers:

Helium-neon lasers are used in industries.

These lasers are used in scientific instruments.

Helium-neon lasers are used in the laboratories.

THANK YOU