HELIUM-NEON LASER

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Main Components

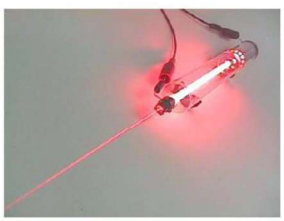
Three main components of **ANY** lasers are

(i) The active medium
(ii) The pumping source
(iii) The optical resonator

- The active medium acts as an **amplifier** for light waves
- For amplification, **medium** should be in a state of **Population inversion**
- Population inversion – **metastable levels** – lifetime is bit longer as compared to excited state
- The active medium placed inside an optical resonator – acts as an **oscillator**
- A pair of mirrors + active medium - optical resonators

Helium – Neon laser

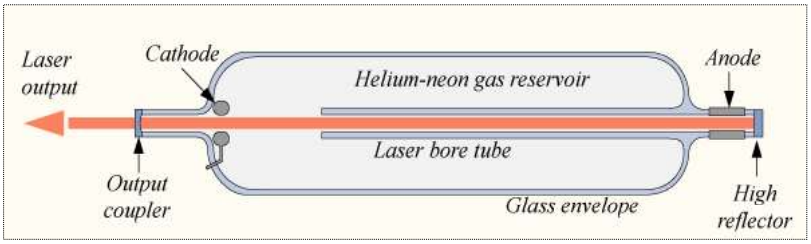
- First continuous laser developed by Ali Javan, W. Bennutt and D. Herriot in 1961
- Operation wavelength is 632.8 nm (red portion of visible spectrum).
- 4-level laser scheme.
- More directional and monochromatic than solid state lasers.
- Output is moderate compared with solid state lasers.
- Active medium is a mixture of He and Ne gas in 10:1 ratio (atomic percentage).
- Ne atoms are active centres for lasing action. He only helps in efficient excitation of Ne atoms.



He-Ne laser – without protective jacket

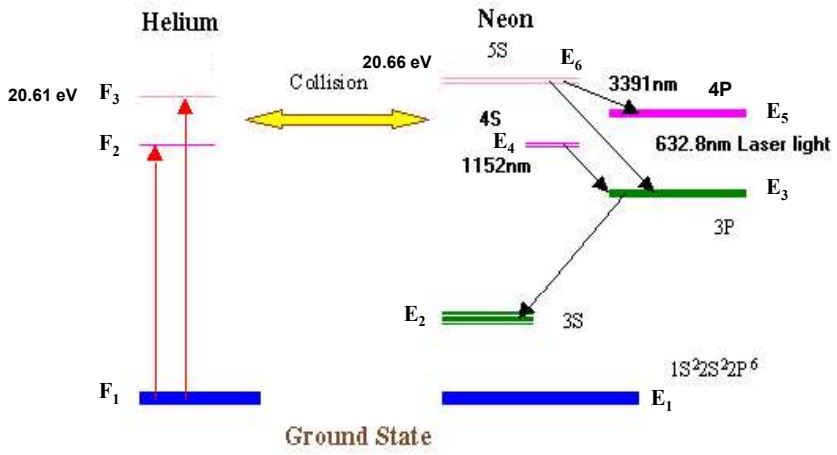
Completely protected commercial He-Ne laser

Construction of He-Ne laser



- ✓ Set up consists of a **discharge tube of length 80 cm and bore diameter of 1.5 cm.**
- ✓ **Gain medium of the laser is a mixture of He and Ne** as the name suggests in ~10:1 ratio. It is contained at **low pressure** (an average 50 Pa/cm of cavity length) in a glass envelope.
- ✓ The pumping is provided electrically by creating an discharge. The **electrical discharge is created by applying ~ 1 KV** through an anode and cathode present at each end of the glass tube. The typical current value ranges from 5 – 100 mA for continuous mode operation.

He-Ne Energy level diagram



$$He + e_1 \rightarrow He^* + e_2 \qquad He^* + Ne \rightarrow He + Ne^*$$

- ✓ When voltage is applied to the electrodes it **ionizes the gas, the electrons and ions** thus produced are accelerated towards anode and cathode respectively.
- ✓ Electrons acquire higher velocity due to its smaller mass when compared to the others. They transfer **K.E to He atoms through inelastic collision**.
- ✓ **He atoms are readily excited by electrons impact** because of its fairly light mass.
- ✓ Thus He atoms are **excited to F_2 and F_3 states which lie at 19.81 and 20.61 eV** respectively.
- ✓ These are **metastable states** and these atoms cannot return to ground state readily by spontaneous emission.

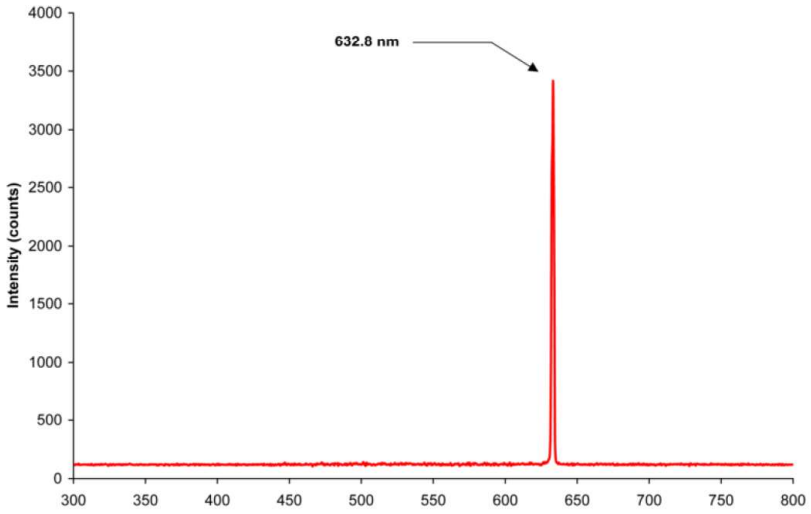
- ✓ These atoms **return to ground state by transferring energy to Ne atom** in the state which has identical energy. Such transfer is called **resonant transfer of energy**. (The direct excitation of Ne atoms is in-efficient compared to He)
- ✓ **Neon energy levels E_6 and E_4 nearly coincide with F_3 and F_2 of Helium,** so resonant transfer can occur.
- ✓ **The additional energy 0.05 eV is provided by the K.E of the He** atom.
- ✓ This **energy exchange process occurs with high probability only because of the accidental near equality of the two excitation energies** of the two levels in these atoms. Thus, the purpose of population inversion is fulfilled.

- ❖ Ne atoms in the E_6 level and E_4 level emit a photon parallel to the axis of the tube.
- ❖ This photon travels through the gas mixture parallel to the axis of tube, it is **reflected back and forth by the mirror ends until it stimulates an excited Ne atom and causes it to emit a photon with the stimulating photon**.
- ❖ In reality neon energy levels E_6, E_5, E_4, E_3, E_2 are not single but a group of lines. Consequently several laser transitions are possible.

- ❖ Three main laser transitions are

1. **E_6 to E_3 – generates laser beam of red colour at 6328Å**
2. **E_4 to E_3 – IR beam at wavelength of 1.15 μm**
3. **E_6 to E_5 – light in Far IR region at 3.39 μm**

He-Ne Laser Spectrum



Applications of He-Ne laser

- 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.

He-Ne lasers uses transitions among the various excited electronic states of an atom.

Advantages	Disadvantages
Emits laser light in the visible portion of the spectrum	Low efficiency
High stability	Low gain
Low cost	Output power is small
Operates without damage at higher temperatures	

CAUTION

Helium-neon lasers are common in the introductory physics laboratories, but they can still be dangerous! According to Garmire, an unfocused 1-mW HeNe laser has a brightness equal to sunshine on a clear day (0.1 watt/cm^2) and is just as dangerous to stare at directly.