CARBON DIOXIDE LASER

(CO_2 Laser)

CO_2 laser was one of the earliest gas lasers to be developed (invented by C K N Patel of Bell Labs in 1964), and is still one of the most useful.

Features of CO2 Laser

- Carbon Dioxide laser is a four-level molecular laser (operates on a set of vibrational-rotational transitions).
- Active Medium: Mixture of CO2, N2, He
- Emit in the Infra Red (IR) Spectrum (λ= 9.6 μm or 10.6 μm)
- This laser is powerful enough to cut many substances and also destroy many others.
- As a continuous wave (CW) laser, this laser beam is the most powerful in production.
- Very simple to operate, and the gasses are non-toxic
- Pumping Method: Electrical excitation, Collisional transfer.

Molecular Gas laser

In a molecular gas laser, laser action is achieved by transitions between vibrational and rotational levels of molecules. Its construction is simple and the output of this laser is continuous.

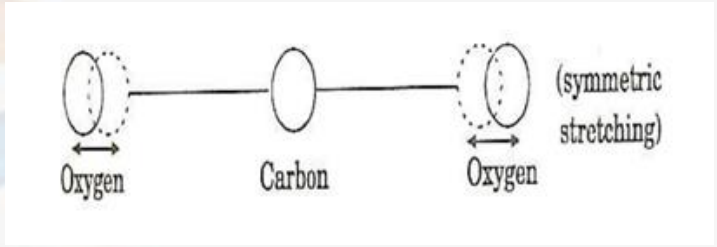
In CO_2 molecular gas laser, transition takes place between the vibrational states of Carbon dioxide molecules.

Energy states of CO2 molecules:

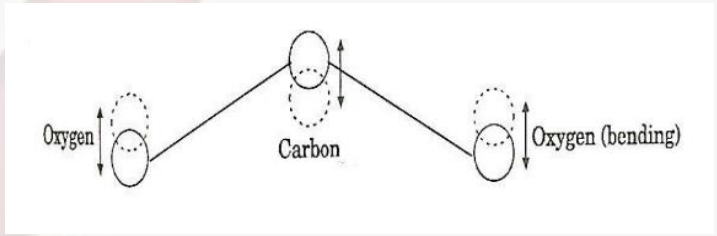
A carbon dioxide molecule has a carbon atom at the center with two oxygen atoms attached, one at both sides. Such a molecule exhibits three independent modes of vibrations. They are

a) Symmetric stretching mode.
b) Bending mode
c) Asymmetric stretching mode.

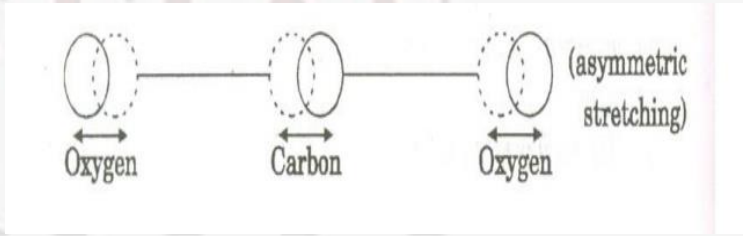
a) Symmetric stretching mode



b) Bending mode



c) Asymmetric stretching mode



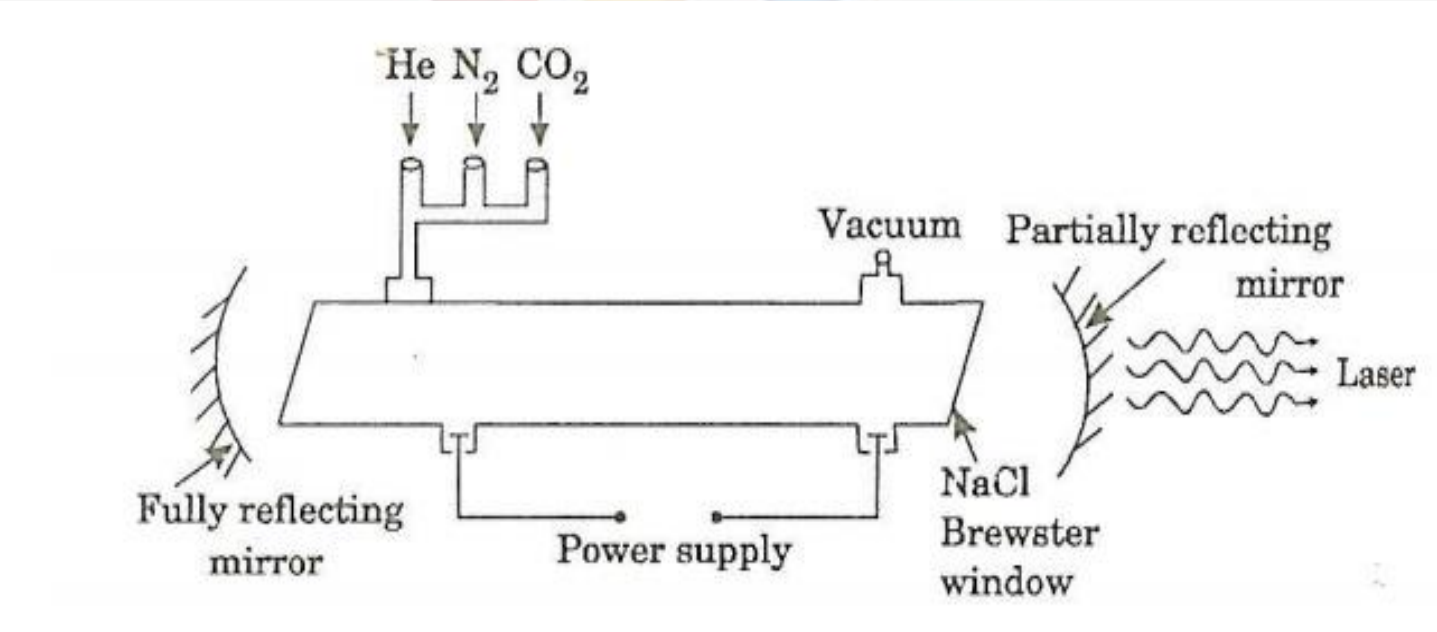
Construction:

It consists of a quartz tube 5 m long and 2.5 cm in the diameter. This discharge tube is filled with gaseous mixture of CO2 (active medium), helium and nitrogen with suitable partial pressures.

The terminals of the discharge tubes are connected to a D.C power supply. The ends of the discharge tube are fitted with NaCl Brewster windows so that the laser light generated will be polarized.
Two concave mirrors one fully reflecting and the other partially form an optical resonator.

Construction:

The active medium is a gas mixture of CO_2, N_2 and He. The laser transition takes place between the vibrational states of CO_2 molecules



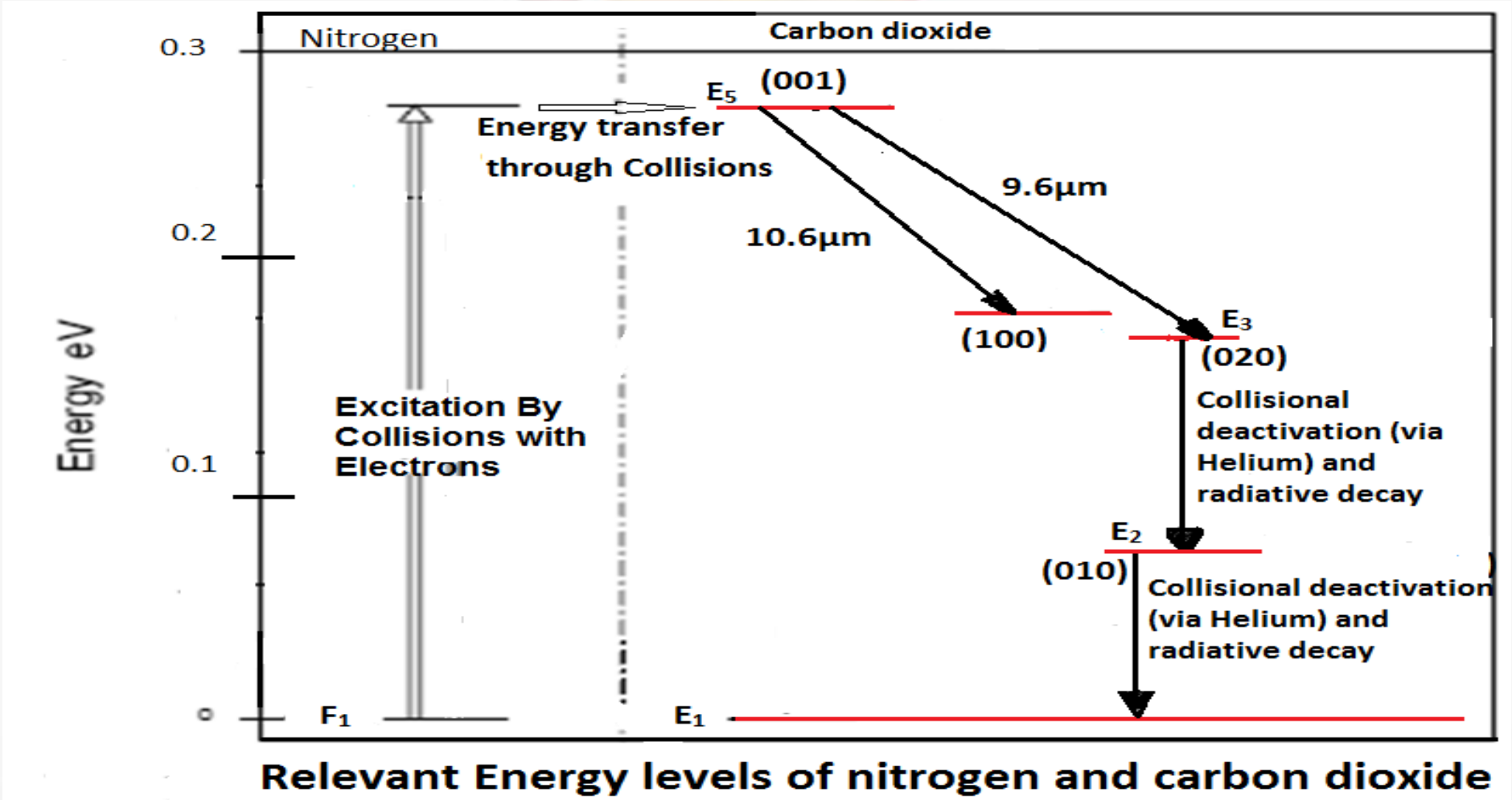
Working of CO_2 Laser

When electricity is run through the gas mixture, the particles of nitrogen become excited, meaning that they gain more energy.

Nitrogen is used because it can hold this excited state for long periods of time without discharging the energy in the form of photons, or light. (Nitrogen plays a similar role as that of He in He-Ne laser).

The excited vibrations of the nitrogen then cause the carbon dioxide to become excited to (E_5) level.

At this point, population inversion has been achieved between (E5) and (E4) giving stimulated emission **(10.6µm)** and (9.6µm) between (E5) and (E3) levels



Relevant Energy levels of nitrogen and carbon dioxide

Contd.....Working of CO_2 Laser

- Helium is used to increase the thermal conductivity of the walls of the tube, efficiency by decreasing the population of (E3), (E2) levels and indirectly depleting the linked (E4) level.

- The light produced is so powerful compared to normal light because the tube of gases in a laser beam is surrounded by mirrors, which serve to reflect at least part of the light traveling through the tube. This reflection of light causes the light waves being produced by the nitrogen to reinforce themselves. This means that the light is amplifying as it travels through the gas tube, only coming out after reaching a certain intensity, making it extremely powerful.

Applications of CO_2 Laser

- Because of the high output power (combined with reasonable cost for the laser), CO_2 lasers are frequently used in industrial applications for cutting , welding and hole drilling
- In medical field Co2 laser are used to destory infected tissue in a wound.
- Because the atmosphere is quite transparent to infrared light, CO_2 lasers are also used for military range finding
- Easily shows the molecular properties of CO_2

Reference Books:

1. B. B. Laud Lasers and Nonlinear optics (2ndEdn.). New Delhi: New Age international (P) Limited(2011)

2. K. Thyagarajan, A. K. Ghatak, Lasers: Theory and Applications. New Delhi: Macmillan India Ltd (2011)

3. L. Allen, Essentials of Lasers. Oxford: Pergamon Press (2017)