**Excitation of a gas laser**

Two main excitation techniques are used for gas lasers:

- **Electrical Discharge**

- **Optical Pumping**

**Excitation of Gas Laser by Electrical Discharge**

Applying high voltage to electrodes at both sides of the tube containing the gas causes electrical breakdown through the gas. Electrons are ejected from the cathode, accelerated toward the anode, and collide with the gas molecules along the way. During the collision, the mechanical kinetic energy of the electrons is transferred to the gas molecules, and excites them. (This same method of energy transfer is used in common fluorescent lights).

**Excitation of Gas Laser by Optical Pumping**

Exciting a laser medium by optical pumping, requires that the absorption spectrum of the medium will be similar to the emission spectrum of the pumping source, so that a big amount of the radiation will be absorbed. Conventional light sources used for optical pumping have broad emission spectrum, so only a small part of the light is used in the excitation process. Because gas atoms absorb only a small portion of the spectrum, optical pumping is not generally an efficient method for gas lasers.

The absorption spectrum of solids are wider than the absorption spectra of gases, so the pumping efficiency of solid state lasers by conventional light sources are higher than that for gas lasers. Thus gas lasers are usually excited by an electric discharge (see previous section). When we want to excite a gas laser by optical pumping; we need to find an optical source with very narrow bandwidth, which fits the narrow absorption spectral lines of the gas. A good source for optical pumping of a gas laser is another laser. This method is used for pumping Far-Infra-Red (FIR) gas lasers by a CO₂ laser.

**Groups of Gas Lasers**

For convenience, gas lasers are divided into 3 groups:
Atoms - The laser active medium is composed of neutral gas atoms such as Helium-Neon and Copper Vapor.

Ions - The laser active medium is composed of ionized gas such as Argon ion gas or Helium-Cadmium gas.

Molecules - The laser active medium is composed of gas molecules, like Carbon Dioxide (CO$_2$), Nitrogen (N$_2$), Excimer laser, Chemical lasers (HF, DF), Far Infra-Red (FIR) laser.

I. Neutral Gas Lasers (Atoms)

The active medium in these lasers is a noble gas in its neutral state, or a metal vapor.

**Laser Characteristics:**

The active gas is used with other gases in a mixture. The extra gas help increase the excitation efficiency. Maximum gain is achieved when the tube diameter is very small. Gas lasers usually operate in the continuous mode.

1.1.1 Helium-Neon (He-Ne) Laser

The Helium-Neon laser was the most common laser until the spread of diode lasers in the last few years. It was first built in 1961 by Ali Javan. The active medium is a noble gas Neon (Ne), and it is a 4 level laser. The energy level diagram of a Helium-Neon laser is described in figure 1.1. Two meta-stable energy levels act as upper laser levels.

The He-Ne laser have two lower laser levels, so quite a few wavelengths can come out of the transitions between these levels. The important wavelengths are:

\[ \lambda_1 = 0.6328 \, \mu m \, (632.8 \, nm), \quad \lambda_2 = 1.152 \, \mu m, \quad \lambda_3 = 3.3913 \, \mu m, \quad \lambda_4 = 0.5435 \, \mu m \]
Figure 1.1: Energy Level Diagram of He-Ne Laser