- The excited Helium atoms collide with the Neon atoms, and transfer to them the energy for excitation.

We may represent the excitation process by the equations:

$$\mathbf{e_1} + \mathbf{He} = \mathbf{He^*} + \mathbf{e_2} \quad \text{and} \quad \mathbf{He^*} + \mathbf{Ne} = \mathbf{Ne^*} + \mathbf{He}$$

Where e_1 and e_2 are the electron energies before and after the collision, and the asterisk indicates that the atom is in an excited state.

Thus Helium gas does not participate in the lasing process, but increases the excitation efficiency so that the lasing efficiency with it increases by a factor of about 200.

Red Wavelength out of He-Ne Laser

Most of the applications of He-Ne Laser use the red wavelength, because it is the strongest line and it is in the visible region of the spectrum. As shown in figure 2.3, this red light is emitted when the Neon atom goes from the energy level labeled 3s to the energy level labeled 2p, a much bigger energy difference than for the other transitions.

A problem with creating this red light is that a Neon atom in state 3s may also emit 3.3913 μm radiation. This emission decreases the population of the 3s level, without producing visible radiation. The solution to this problem is to use a special coating on the laser mirrors which selectively reflect only the red light. This coating causes reflection back into the optical cavity of only the desired (red) wavelength, while all other wavelengths are transmitted out, and not forced to move back and force through the active medium.

In a similar way, other selective reflecting coating can be used on the mirrors to select other transitions. This procedure allows commercial production of He-Ne lasers at other wavelengths in the visible spectrum. For example, orange, yellow and green He-Ne lasers can be produced, but the laser efficiency is much lower than for the red .Commercially, four visible wavelengths of HeNe laser are commonly available, as outlined in Table 2.1, along with gain relative to the 632.8-nm red line.

TABLE 2.1 Commercially Available He-Ne Lasers

Wavelength (nm)	Relative Gain (Compared to 632.8-nm)
543.5 (green)	0.06
594.1 (yellow)	0.07
611.9 (orange)	0.2
632.8 (red)	1

Because of the low gain of the green He-Ne, special low-loss optics are required which are much more critical (and expensive) than red He-Ne optics, Where a small red He-Ne tube might have an output of up to 20 mW, a comparable green tube would be limited to under 3mW.

Optical Cavity of He-Ne Laser

The cavity in a common He-Ne laser uses a semi confocal optical cavity. It is composed of one planar mirror, which reflects about 98% of the light striking it, and a second concave mirror reflecting 100%. This concave mirror has a focal length equal to the length of the cavity (see figure 2.4).This arrangement of the mirrors causes the radiation to be an almost parallel beam.

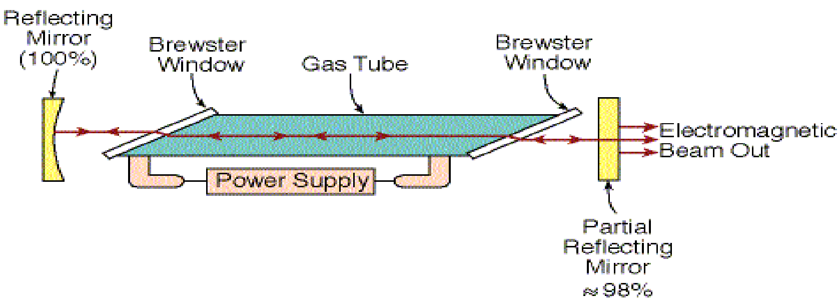

Figure 2.4: The Cavity Structure of He-Ne Laser.

Power Supply of He-Ne Laser

Given the modest current requirements of 5 to 6 mA for an average He-Ne tube ,power supplies are, generally, relatively simple, supplying a run voltage of about1500 to 2000 V. To initialize the lasing action, the gas in the tube needs to be ionized. This action is done with a pulse of maximum voltage of the power supply. This voltage is called the Ignition Voltage of the laser. At the moment of beginning breakdown, the electrical resistance of the tube suddenly falls to a low value. This means that the voltage suddenly drops, while the current rises. Thus, by Ohm's law it is a negative electrical resistance (Decrease in voltage with increase in current).

To overcome this problem, a Ballast Resistor is connected very close to the anode, in series with the power supply. The role of the ballast resistor is to limit the current through the tube to an optimal value and stabilize the discharge. The optimal value of ballast resistance is determined by plotting the voltage-to-current characteristics of the tube and determining the slope of the curve at the desired operating current. The slope of the graph being rise (voltage) over run (current) yields, by definition, resistance. If the optimal operating current is known, the ballast resistance may also be found by measuring the tube voltage at that current. Example: For a laser with operating current of 5 mA, the Ballast Resistor is 60-90 kΩ , and the voltage on it is 300-450 Volts. After lasing action begins, the supply voltage is dropped to about 1,100 Volts, needed for the continuous operation of the laser.

Example: A small He-Ne tube is operated from a power supply which has an output of 1838 V. This particular tube has an operating current of 5 mA and a voltage of 1320 V is across the tube at that current. The required ballast resistance would be

$$R_{ballast} = (V_{supply} - V_{tube}) / I_{tube}$$

$$= (1838V - 1320V) / 0.005A = 104\ K\Omega.$$

A ballast resistance of 104 kΩ is required for the tube. Note that when operating, this resistance has 518 V across it and hence dissipates 2.6 W of heat (power =VI).

QUESTIONS

1. Explain the role of helium and neon atoms in the laser transitions for a He-Ne laser.

2.Why helium gas is used in He:Ne lasers? Which is more percentage the He or Ne? why?

Ans: He gas is used to furnish the pump level (i.e., to assist the population inversion process) in this four-level system, and it is greater abundance or percentage. Helium gas only serves as a buffer gas that enhances lasing by causing the pumping efficiency to be increased. He atoms are so small that they gradually diffuse through the glass walls of the laser tube, lowering the partial pressure of helium. For this reason, most He:Ne lasers are filled with an initial mix He:Ne of 9:1. This ratio is chosen as the optimum for extended tube life, although the actual ratio of He-to-Ne drops with time.

He:Ne = 7.5:1 the optimum ratio for operating (optimum performance).

He:Ne = 9 : 1 the optimum ratio for extended tube life.

For maximum power output, the total gas fill pressure in He:Ne plasma tube is dependent upon the capillary tube diameter, according to the following equation:

P = 0.4/D

Where: P = total gas pressure in torr.

D = tube diameter in cm.

3. A He:Ne laser tube has a bore diameter of 1.2mm. Find: a) total pressure and partial pressure of each gas for optimum performance at 632.8 nm. b) total pressure and partial pressure for each gas for extended tube life.

Ans:

a- For optimum performance:

$$P = \frac{0.4}{D} = \frac{0.4}{0.12} = 3.33 \text{ torr}$$

He : Ne = 7.5 : 1

$$P_{He} = \frac{7.5}{8.5} \times 3.33 = 2.94\ torr, \text{ the He pressure.}$$

$$P_{Ne} = \frac{1}{8.5} \times 3.33 = 0.392 \text{ torr, the Ne pressure.}$$

b- For extended tube life : $P = 1.5 \times P_{optimum}$

P = 1.5 x 3.33 = 5 torr , He:Ne= 9:1

$$P_{He} = \frac{9}{10} \times 5 = 4.5\ torr \quad \& \quad P_{Ne} = \frac{1}{10} \times 5 = 0.5\ torr.$$

4.Explain why the cathode of a He:Ne laser tube is much larger than the anode?

Ans: The anode is a metal (nickel) pin inserted through the glass so that one end extends into the gas region of the tube and the other end is connected to the power supply. The cathode electrode typically consists of a cylindrical aluminum canister a few cm in diameter located inside a glass cylinder. The hollow cylindrical aluminum cathode is made of large surface area (much larger than the anode) for the following reasons:

a- To dissipate the thermal energy and to prevent overheating since it is