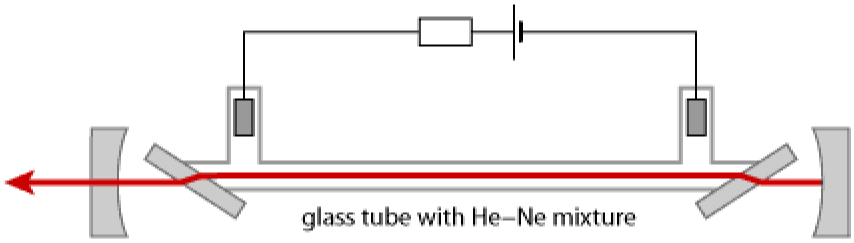
He-Ne Laser

The most common method of exciting gas laser medium is by passing an electric discharge through the gas. In gases the energy levels of atoms involved in the lasing process are narrow and as such require sources with sharp wavelength to excite atoms. Therefore optical pumping is not used in gas lasers.

He and Ne gases are filled in the ratio of 10:1.



The discharge current is limited to about 5 mA by a 91 kW ballast resistor.

The distance over which the waveform remains similar to a sine-wave is called the coherence-length of the beam and it is typically about 10-30 cm for commercial He-Ne lasers. The light is unidirectional and aligned so as to be parallel to the body of the laser. The light is "spatially coherent". The phase of radiation is nearly constant throughout the cross-sectional width of the beam.

Out of the two mirrors one is 100% reflective and other is 99% reflective. A Brewster-window is often inserted in the laser by the manufacturer to produce light with a definite state of linear polarization.

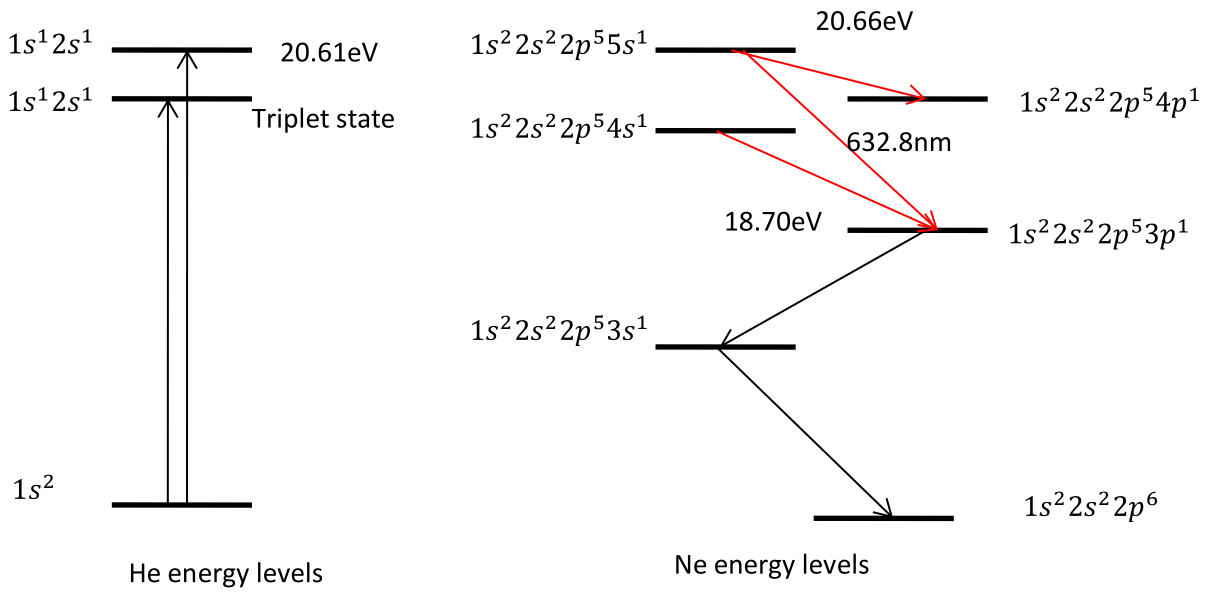
Neon atoms are active centers and are suitable for laser transition whereas Helium atoms help in exciting Neon atoms. Electrodes are provided in discharge tube to produce the discharge. The distances between the mirrors are adjusted $m\frac{\lambda}{2}$ such that the resonator supports standing wave pattern.

Pressure inside the tube is 1/300 to 1/760 atm (1 Torr)

DC voltage is 10kV to start the discharge and 1-2 kV to maintain the discharge. When the power is switched on 10kV of voltage is applied on the electrodes. The gas is ionized and the electrons and ions rush towards anode and cathode respectively. Energetic electrons excite the He atoms in collusion.

He is it's lower energy state has electronic configuration of $1s^2$. After ionization He^+atoms recombine with their electrons. Some He atom end up in $1s^1 2s^1$singlet state.

Neon ordinarily has electronic configuration of $1s^2 2s^2 2p^6$. After excitation it becomes $1s^2 2s^2 2p^5 5s^1$



Red color transitions are stimulated emissions.

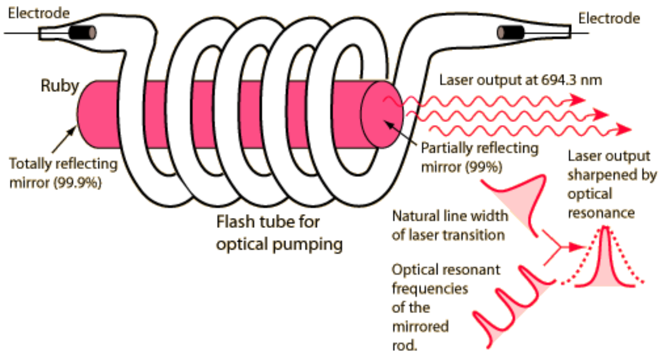
Excited He atom in metastable state $1s^1 2s^1$ cannot return to $1s^2$ by spontaneous emission, however it can transfer some of its energy to Ne atom by collusion. Such energy transfer can take place when two colliding atoms have identical energy levels. Note that $1s^1 2s^1$ for He is 20.61eV and $1s^2 2s^2 2p^5 5s^1$ for Ne is 20.66eV.

The probability of energy transfer from He atom to Ne atom is more as there are 10 He atom per Ne atom.

$1s^2 2s^2 2p^5 5s^1$ is a metastable state. Population inversion is established between this and$1s^2 2s^2 2p^5 3p^1$.The transition from $1s^2 2s^2 2p^5 3p^1$ to $1s^2 2s^2 2p^5 3s^1$ is spontaneous. The wall of the tube is made narrow so that Ne atoms collusion with the wall is frequent and they drop to ground state for next excitation.

Ruby Laser

It is a solid state laser with wavelength λ=694.3nm, deep red color. Ruby's florescence causes stimulated emission. It is a three level laser, with Absorption band 400nm-500nm. Ruby's Florescence time: 3ms helps it in lasing action.



Ruby laser rod is a synthetic Al_2O_3 crystal, doped with chromium ions. Cr^{3+} ions are the actual active centers and have a set of three energy levels suitable for realizing lasing action whereas aluminum and oxygen atoms are inert.

Cylindrical Ruby rod of 4cm length and 0.5 cm diameter is taken. Its ends are grounded and polished so that they are exactly parallel and are also perpendicular to the axis of the rod. One face is silvered to achieve 100% reflection and the other is slivered to give 10% transmission. The laser rod is surrounded with a helical flash lamp filled with xenon.

When flash lamp is activated, the xenon discharge generates an intense burst of white light lasting for few milliseconds.

E_1 electrons are excited to E_3 and E_3' bands. Energy levels in these bands have a very small lifetime (~ 10^{-9}s) and they quickly drop to E_2 a metastable state having lifetime 1000 times more than E_3 or E_3'.

When more than half of Cr^{3+} get accumulated at E_2 level then we say that a state of population inversion is achieved between $E_2$and E_1. Spontaneous emission leads to stimulated emission at E_2 and photons of wavelength 694.3nm are emitted. Those photons travelling along the axis of the of the ruby rod are repeatedly reflected at the end mirrors and light amplification takes place.

The metastable state is depopulated very quickly. The stimulated transition commences and next pulse of xenon flash is triggered to repeat the process.

Applications of Lasers

1. Material Processing: Lasers can cut, drill, and remove metal from surfaces even at otherwise inaccessible areas.
2. Communication
3. Medicine: To burn tissues
4. Military