Helium-Neon Laser and ruby laser

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Helium Neon Laser

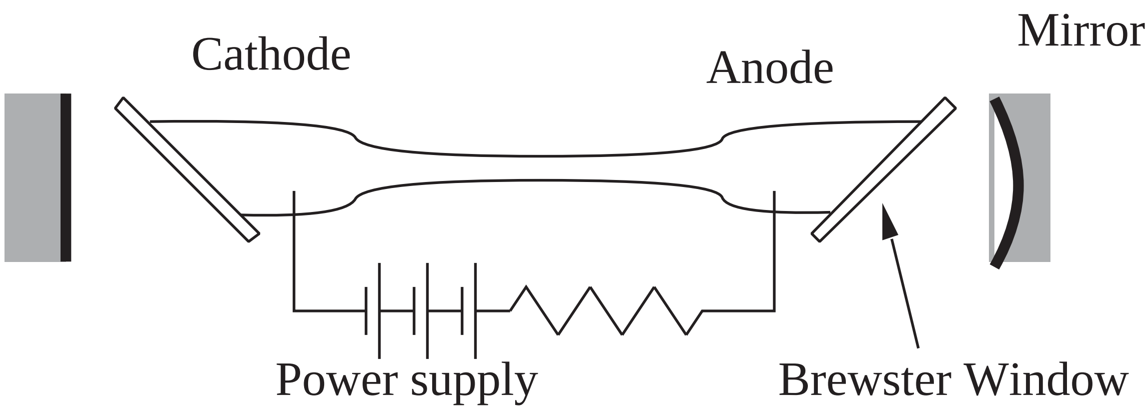
Active Medium: 90% He, 10% Ne, ≈10 torr gas

Pumping: Electrical discharge

Output Wavelength: 632nm, 1.15μm & 3.39μm (select by mirror choice)

Typical power levels: 1-10mW

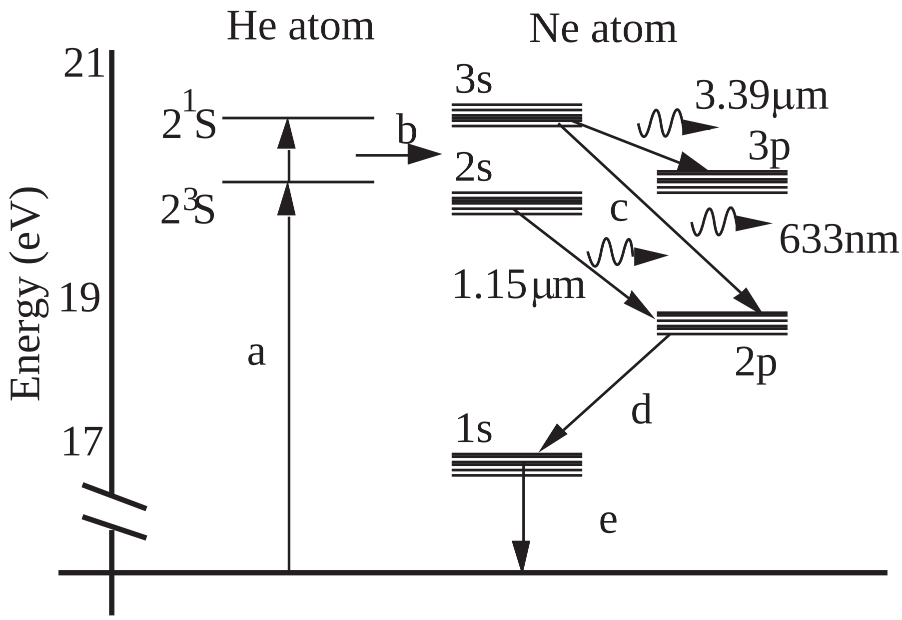
Laser Type: 4 level, inhomogeneous



In the He-Ne laser, the population inversion is created between two energy levels in the neon atoms.

Similar to many other systems pumped by electrical discharge, the neon is excited indirectly.

Energy level diagram for He-Ne laser



a Electron impact excites the helium atoms into the long-lived 2^3S and 2^1S states

b Collision between He and Ne atoms excites the neon into the 2s and 3s states.

c Population inversion created between the 3s/3p and 2s/2p states in neon. Stimulated emission gives gain.

d The lifetime of the 2p and 3p states is short and they rapidly decay to the 1s state.

e Collisions between the neon atoms and the tube walls returns the neon atom to the ground state.

With the He-Ne laser the tube walls play an important part in maintaining the population inversion (step e).

Therefore cannot operate at large tube diameter or high gas pressure.

The ruby laser

Ruby is a crystal of aluminium oxide (Al_2O_3) in which a few chromium atoms are dispersed as impurities ('doped' with chromium). A chromium atom loses three of its electrons and becomes a chromium ion that replaces one of the aluminium ions in the lattice. These chromium ions have a series of energy levels in the visible region (figure 1) which provide the material, that otherwise would be a transparent crystal, with a colour between pink and dark red according to the quantity of chromium present. In the figure, two series of levels are shown so near to each other as to form practically two continuous bands. These two absorption bands are centred at wavelengths of 0.55 µm (green; this band is indicated by spectroscopes as $^4\mathbf{F}_2$) and 0.4µm (blue; this band is labelled as $^4\mathbf{F}_1$) respectively. If the crystal is illuminated with green or blue light, the excited ions relax to two intermediate levels labelled with the letter $^2\mathbf{E}$ in a very short time instead of decaying directly to the fundamental state. The transition from the green or blue band to these levels occurs without light emission

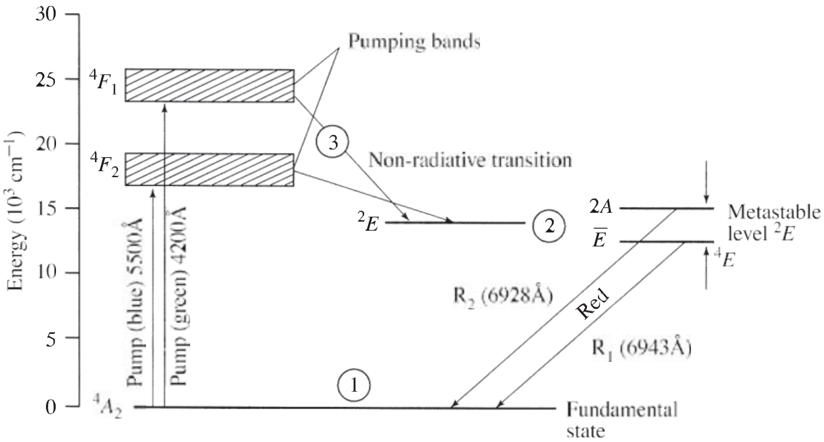


Figure1. Energy levels of the chromium ion in ruby which are involved in laser emission.

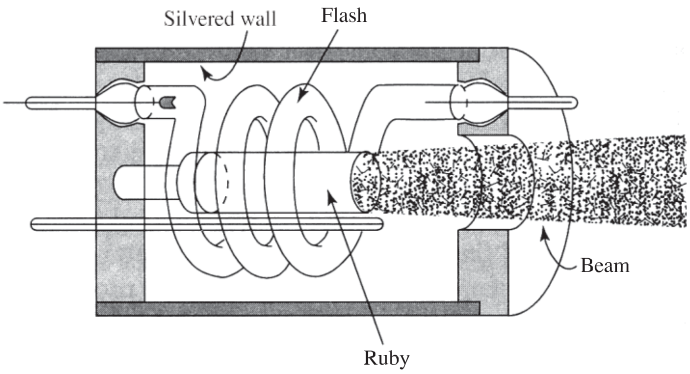


Figure 2. Layout of the ruby laser.