1. Types of Gas Laser

Gas Lasers may be divided into categories in several alternative ways, including the following:

(a) wavelength

ultraviolet
near infrared
far infrared

(b) duration

pulsed
continuous (c.w.)

(c) laser medium

atomic
molecular
ionic

(d) excitation energy

electrical
optical
thermal
chemical

(e) flow regime

static or slowly flowing, inversion in created cavity
fast-flowing, inversion created outside cavity

A wide range of physical processes is involved and a comprehensive review is not possible in the time available. Relevant material may be found in refs. 1-4 and elsewhere.

In these notes we briefly consider first the physical processes leading to population inversion in gases in Sections 2 and 3, then the optical cavity in Section 4. Sections 5 and 6 discuss atomic lasers and Section 7 molecular lasers. Detailed kinetic mechanisms for the HF diffusion chemical laser and the CO_2-N_2 gas dynamic laser are given in Appendices B and C, respectively.

2. Internal Energy Levels in Gases

The internal energy of a gas mixture is made up of the translational, rotational, vibrational and electronic energies of the constituent species of the mixture. For most purposes, contributions may be regarded as additive. It is convenient to assume that translational energies are related through the Maxwell velocity distribution function, characterised by a translational temperature, T, although this is sometimes a poor approximation. For example, in an electric discharge, electron translational energies are generally much greater than those of other particles, and this may be allowed for in an approximate way by introducing a translational temperature, T_e, for electrons, with $T_e >> T$. Note that the assumption of for example a Doppler-broadened spectral line profile implies the existence of a Maxwellian velocity distribution for the radiating species. Also, use of thermally-averaged cross-sections, transition probabilities, etc., implies existence of a unique translational temperature.

Atomic species possess only translational and electronic energy. Figure 1 gives an energy level diagram for the helium atom, and Figure 2 shows energy levels pertienent to the helium-neon laser.

For a diatomic molecular species, the energy level structure is of course more complex because of the appearance of rotational and vibrational states. These can overlap each other, as illustrated in Figure 3, in which v represents the vibrational level number and J the rotational level number. For a rigid rotor, the rotational energy per molecule is

$$E_{rot}(J) = hc\, B_e\, J\,(J + 1) \qquad (2.1)$$

where $B_e = h/8\pi^2 cI$ is the rotational constant in cm^{-1}, and I is the

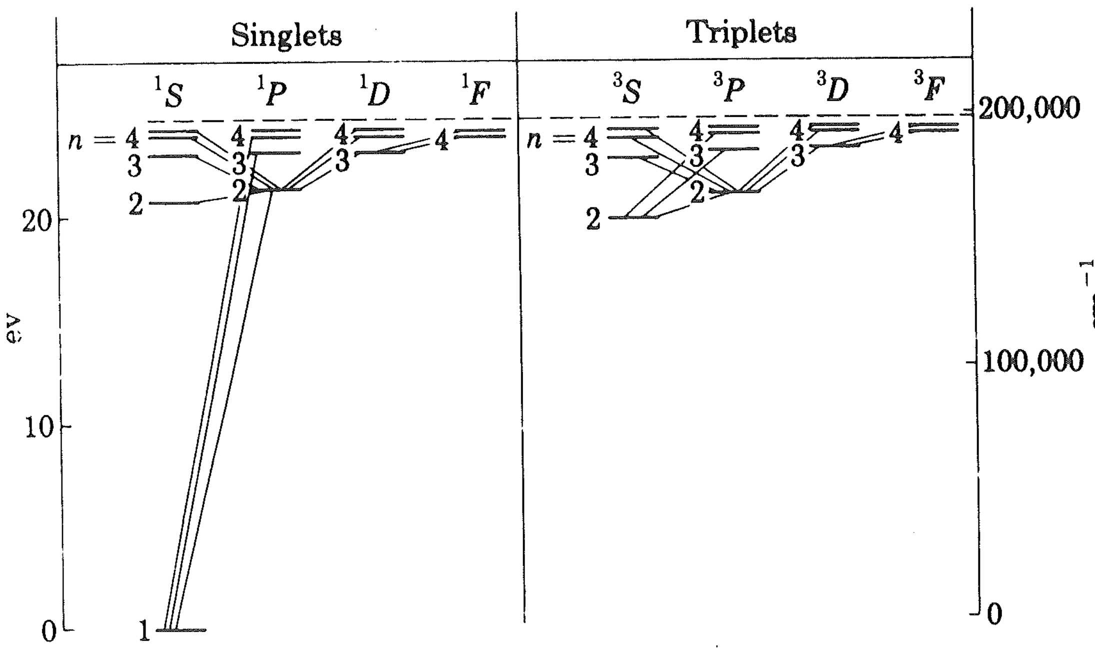

Figure 1 Energy level diagram for the helium atom (ref. 6)