Chapter 1

Background and General Applications

"To have begun is half the job: be bold and be sensible"
Horace 65-8B.C. Epistles ii 40.

1.1. How the Laser Works

1.1.1. Construction

1.1.1.1. Overall Design: The basic laser consists of two mirrors which are placed parallel to each other to form an optical oscillator, that is a chamber in which light travelling down the optic axis between the mirrors would oscillate back and forth between the mirrors for ever, if not prevented by some mechanism such as absorption. Between the mirrors is an active medium which is capable of amplifying the light oscillations by the mechanism of Stimulated Emission (the process after which the laser is named - Light Amplification by the Stimulated Emission of Radiation). We will return to this process in a moment. There is also some system for pumping the active medium so that it has the energy to become active. This is usually a DC or RF power supply, for gas lasers such as CO$_2$, excimer and He/Ne lasers, or a focussed pulse of light for the Nd-YAG laser. It may, however, be a chemical reaction, as with the iodine laser. The optical arrangement is shown in Fig 1.1a,b,c. One of the two mirrors is partially transparent to allow some of the oscillating power to emerge as the operating beam. The other mirror is totally reflecting, to the best that can be achieved (99.999% or some such figure). This mirror is also usually curved to reduce the diffusion lengths of the oscillating power and also to make it possible to align the mirrors without undue difficulty - this would be the case if both mirrors were flat. The design of the laser cavity hinges on the length of
Fig. 1.1. Basic construction of a laser cavity.

a) Stable; b) Unstable; c) Stable cavity with aerodynamic window.

the cavity and the shape of these mirrors, including any others in a folded system.

1.1.1.2. *Cavity Mirror Design*: Kogelnik and Li (1) wrote one of the fundamental papers on cavity design. They showed by geometric arguments that the mirror curvatures at either end of the cavity could only fall within certain values or the cavity would become “unstable” by losing the power around the edge of the output mirror. Cavities can be