1 Background and General Applications

To have begun is half the job: be bold and be sensible
Horace 65–68 BC Epistles I 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 forever, 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 CO₂, excimer and He/Ne lasers, or a focused 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 Figures 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 diffraction losses of the oscillating power and to make it possible to align both 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 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 identified as “stable” or “unstable” depending upon whether they make the oscillating beam converge into the cavity or spread out from the cavity. Most lasers up to 2 kW, use stable cavity designs (Figure 1.1a) because it is safe to transmit that level of power through the output mirror without risk of breakage. The output mirror, being partially transparent to 10.6 \(\mu\)m infrared radiation, is made of zinc selenide (ZnSe), gallium arsenide (GaAs) or cadmium telluride (CdTe) for CO\(_2\) lasers and BK7 fused silica glass for a YAG laser. In all cases it is carefully coated to give the required level of reflection into the cavity (typically a CO\(_2\) laser output window...