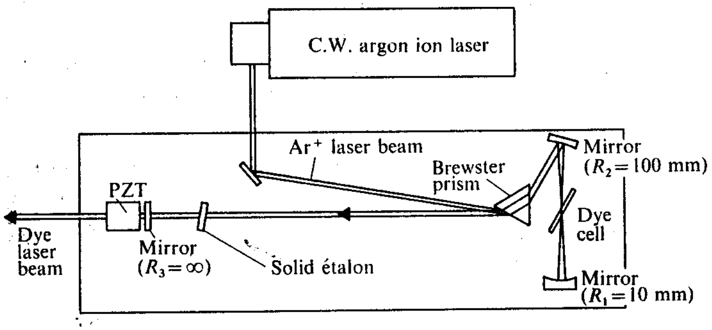

Fig.14.6. Argon ion laser-pumped C.W. dye laser using three mirror cavity. (After Walther (1974).)

by an off-axis, short radius of curvature mirror. The folded arrangement of three mirrors and the Brewster angle prism then form the dye laser cavity and astigmatism is compensated by careful choice of the radii of curvature of the mirrors. Unlike the pumping schemes discussed previously, the single pass gain in C.W. systems seldom exceeds a few per cent and a low-loss optical cavity is necessary for successful dye laser oscillation. This means that diffraction gratings cannot be used as tuning elements; however, even the low dispersion provided by a single prism is sufficient to reduce the output bandwidth to ≈ 0·25 Å, for the amplified radiation now makes a much larger number of transits before leaving the cavity.

In order to reduce the bandwidth still further it is first essential to provide high thermal and mechanical stability, for instance by mounting all the optical components on a massive invar base. Oscillation on a single cavity mode can then be achieved by employing a tilted intracavity étalon and bandwidths as low as 1·5-5·0 MHz have been attained. With this étalon fixed, the dye laser output can be tuned over the free spectral range, c/2L ≈ 500 MHz, of the main cavity by mounting one of the mirrors on a piezoelectric drive and thus varying the length of the cavity. Continuous tuning over the bandwidth determined by the prism is considerably more difficult and requires synchronous tuning of the lengths of both the cavity and the mode-selecting étalon.

For many experiments in atomic and molecular spectroscopy C.W. dye lasers would seem to be the natural choice were it not for the fact that, of all the systems we have discussed, they are the most difficult to operate successfully. Moreover their output is often limited to the 5400-6500 Å region by the fact that only a few dyes such as rhodamine 6G, rhodamine B and coumarin 6 can be made to oscillate on a C.W. basis when the strong blue-green argon lines at 4880 Å and 5145 Å are used as the pump. It is possible to extend the operating range to 4000-7000 Å by pumping with the ultraviolet lines of the krypton or argon ion lasers, but here pump powers of 10-15 W or more are usually necessary.

14.2.5. Comparison of different dye lasers. Representative values of the output power, pulse duration, and tuning range of dye lasers pumped by the four schemes we have just considered are given in Table 14.1. The table also includes values of the minimum output bandwidth but these should be treated with some caution since results in individual cases are very largely determined by the alignment and stability of the dye laser cavity. Moreover this figure may be increased by several orders of magnitude should the number of frequency selective elements in the cavity be reduced.

The range of tunable dye laser radiation may be extended down to 230 nm by frequency doubling or optical sum-frequency generation using non-linear optical materials. Similarly coherent infrared radiation can be generated using difference frequency mixing in non-linear crystals or by stimulated Raman scattering in alkali metal vapours, as indicated in Table 14.2. However, the efficiency of these conversion processes is often rather low, especially in the infrared region, and experiments outside the normal