Other methods for active modelocking

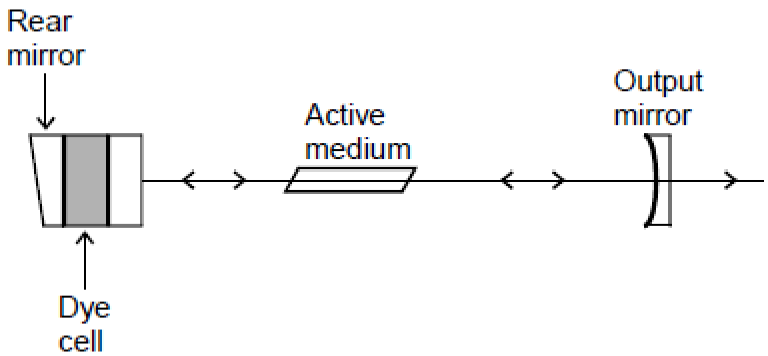
Electrooptic devices can serve the same function as acousto-optic modulators both for active modelocking

A Pockels cell is a particular example of an electro-optic device

Passive modelocking

Uses saturable dye absorbers

There are various designs of passive modelocking, but a dye inside the resonator is a major requirement



In the above configuration a dye cell and the rear mirror are combined to reduce the number of reflective surfaces in the laser cavity, and to minimise unwanted losses.

Let us assume that the absorbing dye in a cell is characterised by the energy levels E_1 and E_2 with $E_2 - E_1 = h\omega$, where ω is the frequency of one of many longitudinal modes in the optical cavity.

If the excited state lifetime τ, is of the order of magnitude of the cavity round-trip time $T = 2L/c$, i.e., a few nanoseconds in typical resonators, the dye molecules act like a passive Q-switching (We have already seen this!).

If the lifetime is comparable to the pulse duration of a modelocked pulse, i.e., a few picoseconds, modelocking can occur.

We have assumed that the absorbing dye in a cell is characterised by the energy levels E_1 and E_2 with $E_2 - E_1 = h\omega$, where ω is the frequency of one of many longitudinal modes in the optical cavity.

light in the optical resonator arriving at the cell-mirror promotes some molecules from the lower level, E_1, to the upper level, E_2, causing losses in the light intensity as a result of absorption by the dye.

Initially, just at the beginning of pumping, the laser gain barely overcomes the losses of the saturable dye. In the early stage of pulse generation, the longitudinal modes are not synchronised in phase, and the laser output represents a chaotic sequence of fluctuations. As a result, both the amplification and dye absorption are not very efficient.

As the pump process continues to increase the intensity above a threshold, light-amplification in the resonator approaches values of the saturation intensity in the dye.

The gain in the laser medium is still linear, but the absorption of the dye becomes non-linear.

With absorption of light at the high intensity the substance undergoes saturation (bleaching), so the condition $N_1=N_2$ is fulfilled (where N_1 and N_2 indicate the number of molecules at the levels E_1 and E_2).

The dye in the cell becomes transparent to the laser beam, which can arrive at the reflective rear mirror and back to the active medium, which in turn causes quick gain amplification.

Now the intensity is sufficiently high, and the amplification in the medium becomes non-linear. $\Rightarrow$ The dye molecules return to the ground state, E_1, after time , and the process of light absorption is repeated.

Therefore, the transmission in the cavity is modulated by successive passages of the high-intensity pulses resulting in a modelocked pulse train appearing in the laser output

Finally, the population inversion is depleted, and the pulse decays.

To summarize, the mechanism of the passive modelocking with the saturable dyes consists of three main steps:

1) linear amplification and linear dye absorption;

2) Non-linear absorption in the dye;

3) Non-linear amplification when the dye is entirely bleached.

Types of LASERs

- **Solid State LASERS**
  - Ruby LASER
  - Nd : YAG LASER
  - Ti : Sapphire LASER
- **Semiconductor LASERs**
- **Atomic and Ionic Gas LASERs**
  - He-Ne LASER
  - Argon LASER
  - Copper Vapor LASER
- **Molecular Gas LASERs**
  - CO_2 LASER
  - N_2 LASER
- **Chemical LASERs**
  - Iodine LASER
  - Excimer LASER
- **Dye LASERs**