

6.2.2 Laser Modes

This module is not finished but you can get a rough idea of what it's all about.

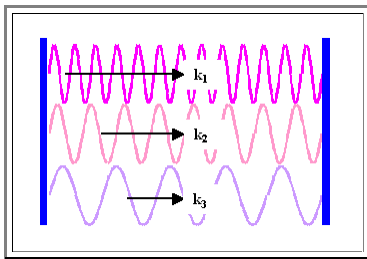
The Fabry Perot resonator introduced in [chapter 6.1.3](#) is an oversimplification of the situation in a *real* semiconductor Laser.

- Without mentioning it, we have assumed an infinitely extended system in the illustrations, i.e. a one-dimensional situation.
- The active region in a real Laser, however, is finite. Often, it consists of a particular material embedded in an other material with a *different* index of refraction; in any case it ends somewhere. In a most simple approximation we may consider it to be a box of length l , thickness d and width w .

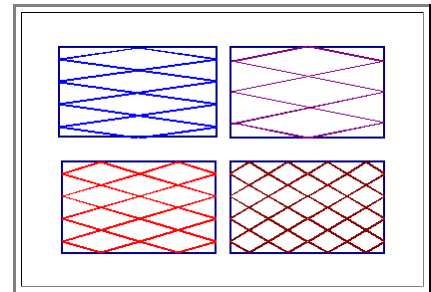
This simply means that *many* standing waves - with different wavelengths and different wave vector directions - satisfy the resonance condition.

- In *other words* - and that is the common lingo - the Laser cavity may contain many internal **modes** and thus does not automatically emit monochromatic light in one direction only.
- We may distinguish between **axial** or **longitudinal modes**, and **transverse** modes. The figures below illustrates this

Longitudinal Modes



Transverse Modes



- Many wavelengths fit in the *longitudinal* direction which we define to be the direction where we want emission. We have

$$l = m \cdot \lambda / 2n_r \text{ and } m = 1, 2, 3, \dots$$

Many transverse modes are possible as shown. They are undesirable and should be avoided.

- Only wavelengths compatible with the band gap energy, i.e. $\lambda = c/n_r \cdot \nu \approx c \cdot h/n_r \cdot E_g \approx \mu\text{m}$ will become amplified, i.e. m is large since l is typically many μm .
- The distance between allowed frequencies is $\Delta\nu = c/2l \cdot \nu \approx 80 \text{ GHz}$ for $l = 500 \mu\text{m}$. The emission lines of the longitudinal modes are thus very close together.

Laser modes, what to do with them, and how to make a Laser working in only *one* mode - this is what we naively expect a Laser to be - is clearly a science in itself.

- We will not go into details, suffice it to say that **monomode Lasers** are possible by optimizing the resonating properties of the cavity to the local gain inside it.