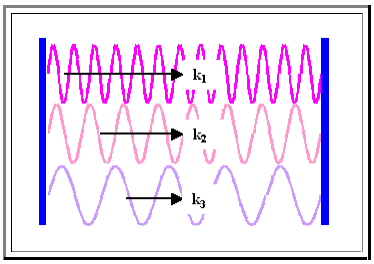
6.2.2 Laser Modes

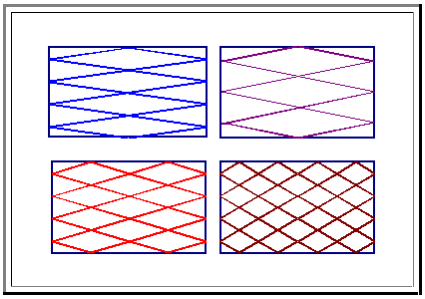
This module is not finished but you can get a rough idea of what it's all about.

- 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
    $l = m \cdot \lambda/2n_r$ and $m = 1,2,3,...$

    Many transverse modes are possible as shown. They are undesirable and should be avoided.
  - Only wavelengths compatible with the band gap energy, i.e. $\lambda = c/n_r \cdot \nu \approx c \cdot h/n_r \cdot E_g \approx \mu m$ will become amplified, i.e. ***m*** is large since ***l*** is typically many **µm**.
  - The distance between allowed frequencies is $\Delta\nu = c/2l \cdot \nu \approx 80\ GHz$ for $l = 500\ \mu m$. 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.