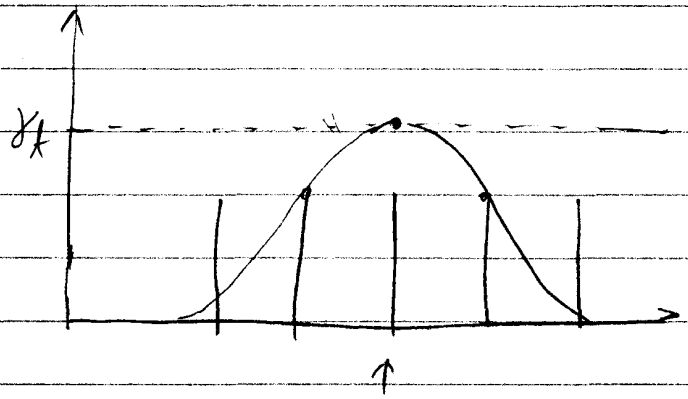
03/04/05 Lecture 19 6

Finish up laser theory

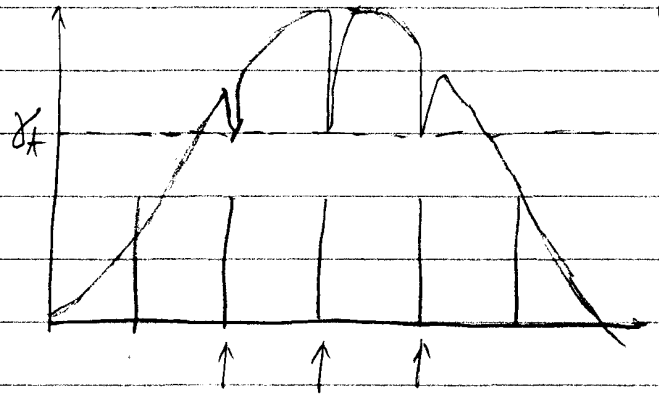
Last time discussed output spectrum

Homogeneous broadening:



one mode lasing

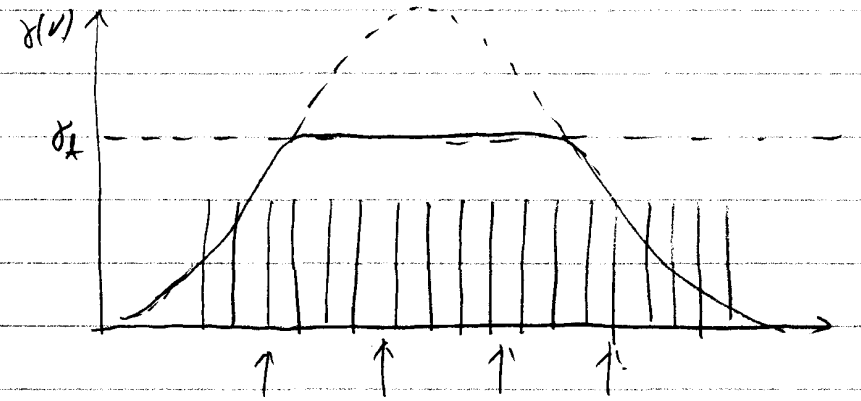
Inhomogeneous broadening:



"spectral hole burning"

several mode lasing

or often have $\Delta\nu_{IH} \gg \Delta\nu_H \gg \nu_F$



several mode lasing, seperated by $\Delta\nu_H$

mode hopping common.

Note: even homogeneously broadened lasers tend to be multimode:

"spatial hole burning" → standing waving cavity

To get rid of "spatial hole burning" → a ring cavity
traveling wave.

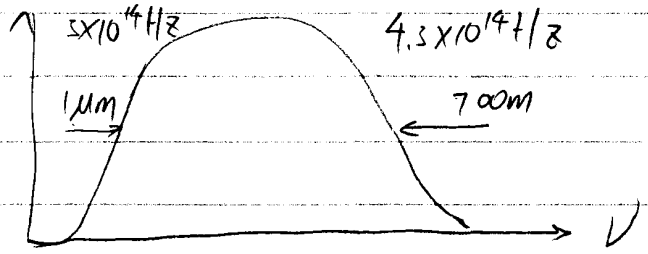
Often important: some form of mode selection
elimination of unwanted mode.

Example: Ti: Sapphire laser, gain 700nm ~ 1μm

Very tunnable

very convenient

but how to achieve single mode?

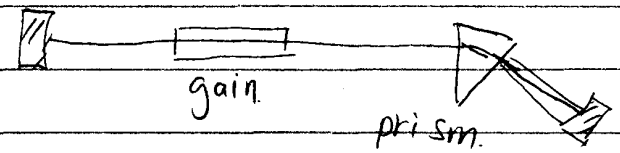


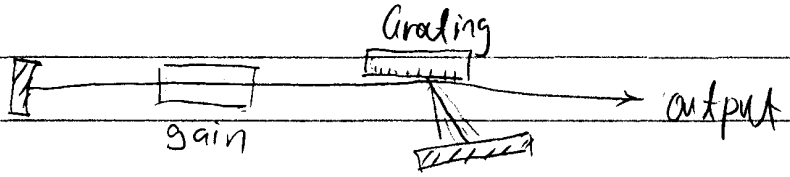
$\nu_F = 300MHz$

Put filters in cavity:
many kinds. from coarse to fine

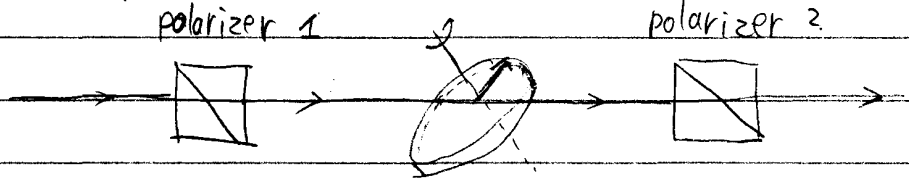
1) Mirrors:
Mirror reflection bandwidth ~ 100 - 200 nm
out side this range cavity losses high
often used to select among different possible laser transitions.

2. Prisms / Grating: diffraction
$\Delta\lambda \sim 1 - 10\,nm$ $\Delta\nu = \frac{c\Delta\lambda}{\lambda^2}$
for $\lambda \sim 500\,nm$





3 Birefringent filter



Birefringent plate.

Ordinary and extraordinary components experience different phase shift:

$$\Delta\phi = 2\pi (n_e - n_o) L_e / \lambda$$

(L_e: thikness of birefrigent)

$\Delta\phi$ is an integral number of 2π

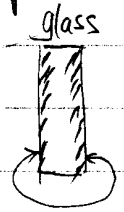
$$\frac{2\pi (n_e - n_o) L_e}{\lambda} = 2k\pi$$

then the output and input have same polarization, maximum transmission.

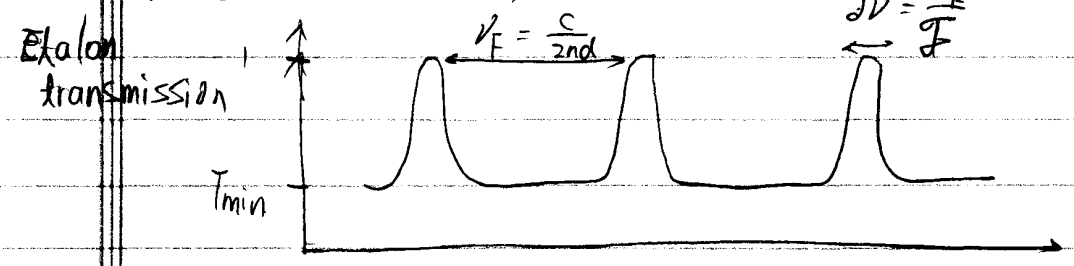
By tuning Birefringent plate, n_e can be changed, therefore the transmitted wavelength λ can be changed.

$$\Delta\nu \sim 10^{16}\ Hz, \qquad \Delta\nu_F = \frac{c}{(n_e - n_o) L_e}$$

4) Etalon: Simple Fabry-Perot resonator



placed in cavity



use with other filters

choose ν_F (etalon) > bandwidth of other filter
only one etalon mode selected

Usually set $\delta\nu \approx \nu_F$ (cavity) or $\Delta\nu_H$ (whichever is larger), so that one laser mode is selected.

Example with 10 GHz birefringent filter

take ν_F (etalon) $\approx$ 10 GHz
$\Rightarrow d = 1\,cm$

0.5 cavity length ν_F (cavity) = 600 MHz

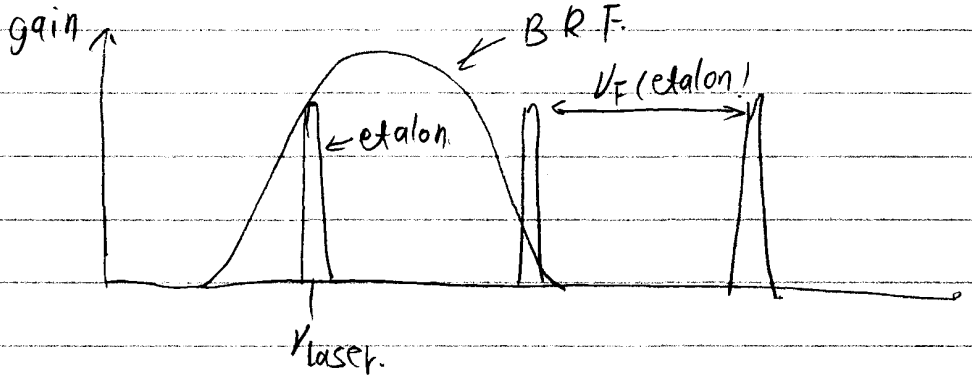
take $\delta\nu = 600\,MHz$

$$F = \frac{\nu_F}{\delta\nu} = 15$$

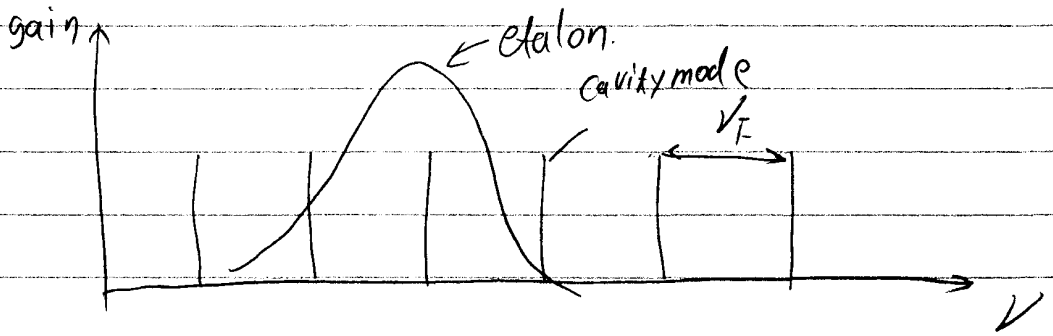
Tune frequency by slightly tilting etalon

① gain

② zoom in



③ zoom in



Laseris with long ($l > m$) cavities usually need
2 etalons one thine (coarse)
one thike (fine)