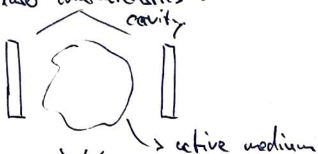
A 246 - High Resolution Laser spectroscopy

▷ Diode laser characteristics :

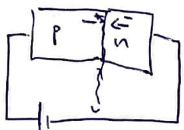
general



Besetzungs-inversion
↳ coherent laser emission

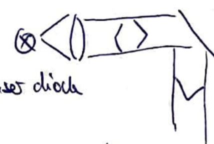
pump → Current for $I > I_{thr}$ the power increases linearly

single diode laser: p-n junction in forward bias : (homojunction)



better : double heterojunction → smaller active region → high divergence and also astigmatism

LITTROW configuration → smaller linewidth

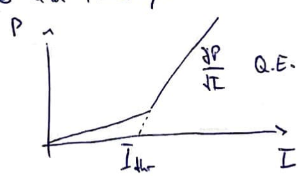


PZT → allows scanning the output wavelength

$$\Delta\omega^2 + \Delta\omega^2 \cdot \frac{x}{P_{sat}} = 0 \iff x = -P_{sat}$$

Tuning of output frequency : - Laser temperature (slow)
- Laser current (fast)
- grating angle (only in single mode)

▷ Laser power and intensity :



$\frac{\partial P}{\partial I}$ $\quad Q.E. = \frac{\partial P}{\partial I \cdot V}$

$$T(\omega) = e^{-\alpha \frac{1}{\sqrt{1+s}} \cdot L} \approx 1 - c\alpha \frac{1}{\sqrt{1+s}}$$

$$A_{mp} \propto A = 1 - T = \frac{c}{\sqrt{1+s}}$$

▷ FABRY - PEROT interferometer

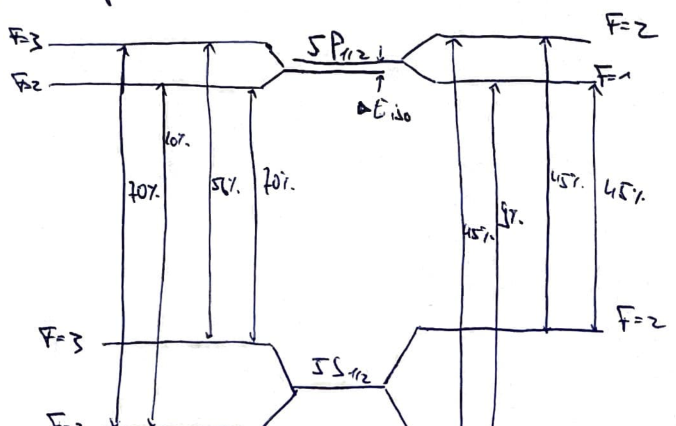
periodic transmission : $T_{FPI} = \frac{1}{1 + F\sin^2 \varphi/2}$ $\qquad \frac{\varphi}{2} = nk_0L = \frac{n\omega L}{c}$

$F = \frac{4R}{(1-R)^2}$

free spectral range : $\Delta\omega_{FSR} = \frac{c}{2nL}$

$FWHM = \frac{\Delta\omega_{FSR}}{\mathcal{F}}$ $\qquad \mathcal{F} = \frac{\pi\sqrt{R}}{1-R}$ $\qquad$ considering also transv. modes : $\Delta\omega = \frac{\Delta\omega_{FSR}}{2} = \frac{c}{4nL}$

▷ Properties of rubidium Notation: $n^{2S+1}L_J$



^{85}Rb

$I = 5/2$

$F = 2, 3$

^{87}Rb

$I = 3/2$

$F = 1, 2$

$$\Delta E = \frac{A}{2}\left(F(F+1) - I(I+1) - J(J+1)\right)$$

▷ linear spectroscopy

- LAMBERT-BEER: $T(\omega) = e^{-\chi(\omega)L}$ $\chi(\omega) = \chi_0 \dfrac{(\Delta\omega/2)^2}{(\omega-\omega_0)^2 + (\Delta\omega/2)}$ (LORENTZ)

  ↳ natural width $\tau = \frac{1}{\Gamma} = \frac{1}{2\pi\Delta\omega}$

- DOPPLER-width: $\chi_D(\omega) = \chi_D(0)\exp\left[-\dfrac{(\omega-\omega_0)^2}{2\Delta\omega_D^2}\right]$

  ↳ obtained by convoluting $\chi(\omega)$ with velocity distribution

▷ non-linear spectroscopy

- saturation spectroscopy: significant fraction of atoms is in excited state

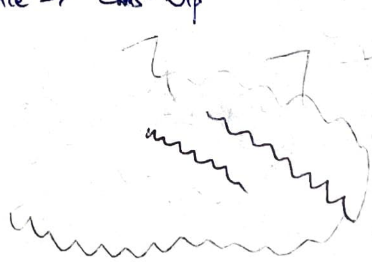
  $\chi(\Delta\omega) \to \chi(\Delta\tilde{\omega})$ $\Delta\tilde{\omega} = \Delta\omega\sqrt{1+s}$

  absorbed power: $\Delta P \propto \dfrac{s}{\sqrt{1+s}} \to \infty$ for $s \to \infty$ "optical power broadening"

pump beam: burn BENNET-hole into absorption spectrum

probe beam: measure the absorption on resonance → LAMB-Dip

cross-over resonances → as name suggests



$$E = h\cdot\omega = h\cdot c/\lambda$$

$$\omega = c/\lambda$$

$$\lambda = c/\omega$$