# Homework 7 - Lasers

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1. Work through the practice problem on the last two pages of the class notes. In addition, work out the spectral sharpness in microns for an individual lasing mode. ($\Delta\lambda = 6.41 \times 10^{-16}$ meter)

2. In the Ruby laser, saphire ($A1_2O_3$) is doped with $Cr_2O_3$ to produce Pink Ruby with $2.0 \times 10^{19}$ chromium atoms/cm$^3$. If 1% of this Cr density is inverted such that $N_2 - N_1 = 2.0 \times 10^{17}$ cm$^{-3}$, the resulting peak gain coefficient is $g_o = 2 \times 10^{-2}$ cm$^{-1}$. Other conditions are

$\lambda_o$ = 0.6943 µm
n = 1.77
$\Delta\nu$ = $2 \times 10^{11}$ Hz at 300 K
d = 2 cm cavity length
L = 2 cm crystal length
$N_2$ = upper state population density
$N_1$ = ground state population density.

(a) Find the output mirror reflectivity to just permit 21 longitudinal modes to lase. Assume the middle mode frequency is centered at the peak of the Doppler broadened gain profile and the back mirror reflectivity is 100%.

(b) Suppose the upper state populations have fully relaxed to thermal equilibrium conditions; find the resulting absorption coefficient ($\alpha_{abs}$) at 0.6943 µm.

Answers:

(a) $\Delta\nu_{mode} = \Delta\nu_{fsr} = 4.237$ GHz
$g_{threshold} = 0.0177$ cm$^{-1}$ => $R_2 = 93.2\%$

(b) $g_{max} = 0.02$ cm$^{-1}$ => $N_2 - N_1 = 2 \times 10^{17}$ cm$^{-3}$
$\alpha_{max} = (2 \times 10^{19}/2 \times 10^{17})\, g_{max} = 2$ cm$^{-1}$