ENEE 496 Spring 2004
Solutions to First Examination Questions

(1) Homogeneous broadening affects all particles equally -- all paticles are identical.
Examples: natural broadening, pressure broadening, Stark broadening.

Inhomogeneous broadening results because nonequivalent particles are bein observed, which have different center frequencies.
Examples: Doppler broadening, different environments in a real crystal or glas

Lorentzian line shape is derived by carrying out Fourier transform on

$$e(t) = E_0 \cdot \cos(\omega t)\, e^{\frac{-t}{\tau_c}}$$

If $\tau = \frac{1}{A_{21}}$ $\qquad \Delta\nu = \frac{A_{21}}{2\cdot\pi}$

If $\tau = \frac{1}{A_2}$ $\qquad \Delta\nu = \frac{A_2}{2\cdot\pi}$

Including lower level $\Delta\nu = \frac{A_2 + A_1}{2\cdot\pi}$

(2)

$$I = I_{0e}^{\gamma 0(\nu)\left[1-\frac{(I-I_0)}{I_S}\right]}$$

$$g(\nu_0,\nu) = \frac{\frac{2}{(\pi\cdot\Delta\nu)}}{1+\left[\frac{2\cdot(\nu-\nu_0)}{\Delta\nu}\right]^2}$$

$$\gamma(\nu) = \frac{\gamma(\nu_0)}{\left[1+\left[\frac{2\cdot(\nu-\nu_0)}{\Delta\nu}\right]^2\right]}$$

$I0_S := 10$ saturation intensity at line center

$\gamma_0 := 5 \cdot 1000$ At $\Delta\nu$ from line center line shape is 1/5 of peak value

$I_0 := 10$ $l := 10^{-2}$

$\Delta\nu := 10^{10}$

$$g := \frac{1}{1 + \left(\frac{2 \cdot 5 \cdot 10^8}{\Delta\nu}\right)^2}$$ relative line shape function 500 MHz from line center

$g = 0.99$

$$I_S := \frac{I0_S}{g}$$

$I_S = 10.1$ saturation intensity for problem

$I := 10.1$ Guess

Given

$$I = I_0 \cdot e^{\gamma_0 \cdot l - \frac{(I - I_0)}{I_S}}$$

$Iout := Find(I)$

$Iout = 475.986$

Without gain saturation $Iout := I_0 \cdot e^{\gamma_0 \cdot l}$

$Iout = 5.185 \times 10^{22}$

(4) $\lambda 0 := 10^{-6}$ $h := 6.626 \cdot 10^{-34}$ $k := 1.38 \cdot 10^{-23}$

$c := 2.998 \cdot 10^{8}$ $T := 300$

Ratio required is

$$R = \frac{B \cdot \rho(\nu)}{A} = \frac{c^3}{8 \cdot \pi \cdot h \cdot \nu^3} \cdot \rho$$

$$\nu := \frac{c}{\lambda 0}$$

$$\rho := \frac{8 \cdot \pi \cdot h \cdot \nu^3}{c^3} \cdot \frac{1}{e^{\frac{h \cdot \nu}{k \cdot T}} - 1}$$

$$\rho \cdot 10^{35} = 2.415$$

$$R := \frac{c^3}{8 \cdot \pi \cdot h \cdot \nu^3} \cdot \rho$$

$$R \cdot 10^{21} = 1.45$$

Ratio is 1.45×10^{-21}

g

ss.