KFUPM
Department of Physics
Phys412

Homework # 10

Due on Saturday, May 26, 2007

Problem 1

Suppose you have an ideal four-level laser for which B = 1, $V_a$ = 1, $\tau$ = 0.1, and $\tau_c$ = 0.1, where B is the stimulated emission rate per photon, $V_a$ is the volume of the active medium, $\tau$ is the lifetime of the laser upper level and $\tau_c$ is the life time of the cavity. Assume initially you have one photon in the cavity.

a- Solve the two rate equations numerically as a function of time and show that number density of the upper level N and the number of photon in the cavity $\phi$ reach a steady state value within a time of about $10\times\tau$ or $10\times\tau_c$. Test this fact for pumping below and above threshold pumping, say $R_p = 0.1\ R_{pc}$ and $R_p = 10\ R_{pc}$.
b- Solve the two rate equations numerically and find the value of N and $\phi$ for time much lager than $\tau$ and $\tau_c$ , say $100\times\tau$ for different pumping rate $R_p$. Plot N and $\phi$ as a function of $R_p$ and compare the numerical solution with the analytical values obtained in you textbook.

Problem 2

A He-Xe laser has an optical cavity length of $L_e$ = 0.1 m, and its transition at 3.51 μm is mainly Doppler broadened with a FWHM of $\Delta\nu_0 \approx 200$ MHz. If the logarithmic loss per pass $\gamma$ = 0.5, calculate the ratio $\Delta\nu_0/\Delta\nu_c$ between the width of laser transmission and cavity mode resonance. Estimate the frequency pulling of laser emission when the cavity mode resonance $\nu_c$ is detuned from the center of the gainline $\nu_0$ by $\nu_0-\nu_c$=50 MHz.

Problem 3

Estimate the Schawlow-Townes limit to the laser linewidth due to spontaneous emission of a single-longitudinal-mode A Nd:YAG in a ring cavity oscillating at 1.064 μm. The laser has an output power of 50 mW, an optical length of the cavity $L_e$ = 15 cm, and a logarithmic loss per pass $\gamma$ = 0.02.

Problem 4

In a laser which can be considered as space-independent four-level laser, the threshold pump power $P_{th}$ was measured to be 500 mW if the output

coupler has reflectivity of 85% and $P_{th}$ = 400 mW if the reflectivity of the output coupler is 90%. Estimate the internal logarithmic loss of the laser assuming the second laser mirror is perfectly reflecting.

Problem 5

a Ti:sapphire laser operating at 780 nm is tuned by a birefringent plate inserted at Brewster angle. The plate is rotated such that the ordinary and extraordinary refractive indices are $n_0$ = 1.535 and $n_e$=1.544, respectively. Find the plate thickness for which the wavelength separation between two consecutive transmission maxima is 5 nm.