KFUPM
Department of Physics
Phys412

Homework # 11

Due on Saturday, June 9, 2007

Problem 1

We would like to do a numerical study of the effect of a step-function pump on an ideal-four-level laser. Take $V_a = 10$, $B = 0.01$, $\tau = 100$; $\tau_c = 0.1$, $R_p = 50\ R_{pc}$, $N(t=0)=0$, and $\phi(t=0)=1$. Suppose the pump is switched on at $t = 0$. Using the rate equations, plot the population inversion and the number of photons in the laser cavity as a function of time from t=0 to 20. Check that the peak of ϕ occurs when $N = N_c$.

Problem 2

We would like to simulate Q-switching pulse generation. Assume an ideal four-level laser with the laser upper level lifetime of $\tau = 25$. The laser is pumped at a rate of $R_p(t) = \frac{t}{1+t} e^{-3\frac{t}{\tau}}$. Assume that τ_c is changed instantaneously from $\tau_{cH} = 0.001$ (high loss) to $\tau_{cL} = 1$ (low loss) at $t = \tau$. Plot $\frac{N}{N_c}$, $R_p(t)$, τ_c, and $\frac{\phi}{V_a N_c \tau_{cL}}$ as a function of time from t = 0 to t =500. Let $N_c = 0.25$ where N_c is the critical population for the low-loss cavity case.

Problem 3

A solid state laser has a cavity of length 30 cm and active medium of length 1 cm and refractive index of 1.45. The laser output coupler has a transmission of 20%, the other laser mirror has power reflectivity of 100%, and the internal logarithmic laser loses per pass is 5%. Assume the stimulated cross section is 1.9×10^{-19} cm^2, the cross sectional area of the laser beam through the active medium is 7.9×10^{-4} cm^2 and the laser wavelength is 1053 nm. Calculate the energy and pulse duration of the fast Q-switched pulses when the energy of the pump is twice the threshold value.

Problem 4

Suppose your ideal laser oscillates in 41 longitudinal modes which you may treat as sinusoidal waves. All the 41 waves have the same amplitude and their frequencies is given by

$$\nu_i = 100 + 0.1(i - 21), \qquad I = 1, 2, \ldots, 41$$

What is the time over which the laser intensity repeats itself? What is the width of the pulse if these modes are phase locked? Plot the average intensity of the laser for two cases, in the first case, the phases of the waves are totally uncorrelated and, in the second case, the phases of the waves are locked according to

$$\phi_i - \phi_{i-1} = 0.1.$$

Take the average over the period of the central frequency.

Problem 5

According to your textbook on the bottom of page 295 “any element exhibiting a transmission that changes with frequency also induces a phase shift on the incident wave that depends on frequency. For a FP interferometer used in transmission, the phase shift can be obtained from Eq. 4.5.4).” Find an expression for the phase shift caused by FP. Use Mathematica to plot the phase shift along with transmission as a function of phase for the case of a FP with mirrors each of which has a power reflectivity of 0.90.