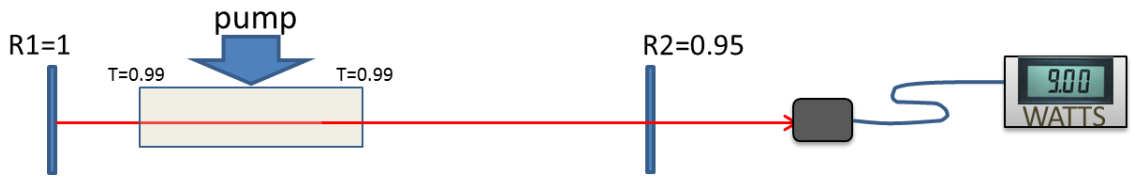
Laser Physics I (PHYC/ECE 464), Fall 2022

Homework #10, Due Monday, Nov. 21

1. Consider the laser system below with an output power measured at 9 Watts. The beam radius inside the gain medium is w~100 μm.



a. What is the threshold integrated gain (g_{th})?

b. What is the (total) power inside the gain medium? (Assume high-Q cavity)

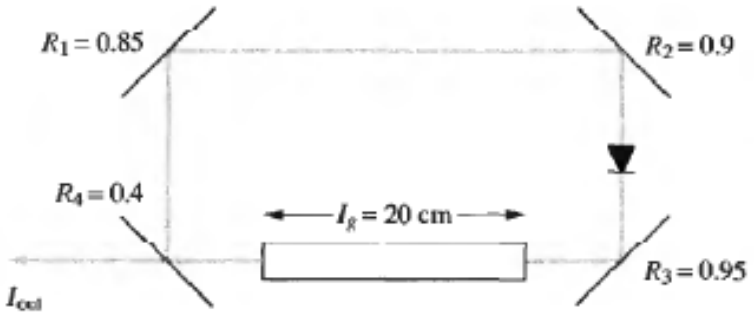
c. This output power (9 W) is obtained when pumped 6-times above threshold. What is the saturation intensity I_s of the gain medium?

d. Is the output coupling optimum? If not, what is the optimum output coupling and what would be the maximum output power?

e. The spontaneous emission (fluorescence) from the sides of the gain medium is simultaneously monitored. If we block the cavity to stop lasing, what happens to the intensity of the fluorescence and why? *(Note: This is similar to last week's HW)*

2.

The small signal gain of the amplifying medium shown below is 6 dB (i.e., $G_0 = 4$) at 1.05 μm. The medium has a stimulated emission cross section of 10^{-17} cm^2, an upper state lifetime of 500 μs, and 10 ns for the lower. There is a 2% loss per surface at the end surfaces of the gain cell. The optical diode can be considered as perfect. Compute the output intensity.



3.

The following questions refer to a ring laser similar to that of Problem 9.8. The cavity specifications are as follows: $R_1 = 0.96$, $R_2 = 0.8$, $R_3 = 0.97$, $R_4 = 0.98$, $T_1 = T_3 = T_4 = 0$, $T_2 = 0.2$. The wavelength of the transition is 760 nm, which originates at a state at $E_2 = 3.2$ eV; the stimulated emission cross section is 2×10^{-20} cm^2; the upper-state lifetime is 1.54 ms and is pumped directly from the ground state at a rate R_{02}; and the lower-state lifetime is negligible (i.e., $N_1 = 0$ always). For the purpose of this problem, assume only the counterclockwise wave is oscillating.

(a) Find the upper-state density required to reach threshold, assuming steady-state operation.

(b) Estimate the pumping power (per unit volume) R_{02} required to reach threshold. (NOTE: Neglect stimulated emission for this part of the calculation.)

(c) Compute the output intensity (W/area) of the laser if the pumping rate was 1.5 times that required to reach threshold.