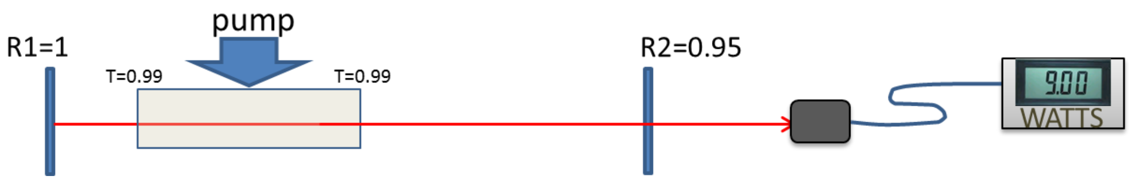
PHYS 564, Laser Physics II

Spring 2021

Homework #1, Due Wed. Jan. 27

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})? 1 points

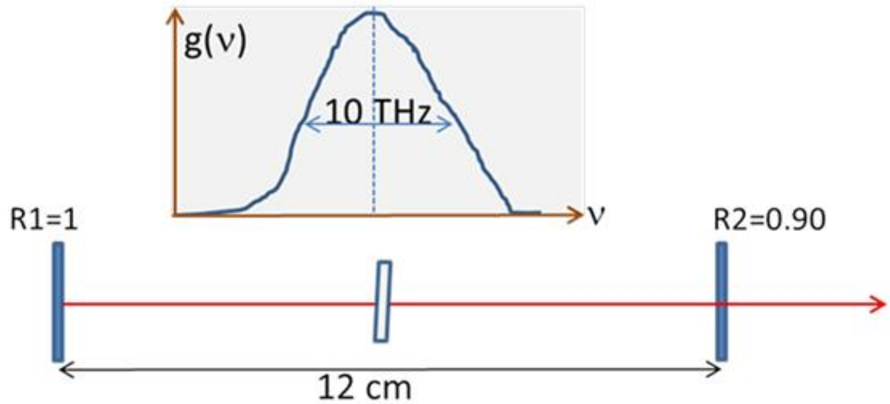
b. Estimate the (total) power inside the gain medium. (Assume high-Q cavity) 1.5 points

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? 2 points

d. Is the output coupling optimum? If not, what is the optimum output coupling and what would be the maximum output power? 3 points

e. The spontaneous emission (fluorescence) from the sides of the gain medium is also monitored. If we block the cavity to stop lasing, what happens to the intensity of the fluorescence and why? Quantify your answer. 2.5 points

2. Consider the laser system shown:



a. If Q-switched, approximately sketch the pulse shape assuming two cases of (i) one and (ii) two longitudinal modes? Be semi-quantitative on your time-axis. 2.5 points

b. If cw- modelocked, approximately sketch the pulse train assuming the shortest pulse. How many longitudinal modes will oscillate? Be semi-quantitative on your time-axis. 2.5 points

c. Considering that the refractive index is wavelength dependent in the gain medium and cavity optics, what do we need to do to ensure the shortest possible pulse? Explain. 2.5 points

d. Consider a Yb^{3+} fiber amplifier at λ=1030 nm with a diameter of D=100 μm and length L_g= 1 meter. The concentration of Yb is N_0= 1.5×10^{20} cm^{-3} and upper state lifetime τ_2=3 ms. What is the maximum power that can be extracted from this laser (i.e. the maximum P_{out}-P_{in})? Explain your answer. 2.5 points