ELEC-E3210 Optoelectronics **Jan 24, 2019**

Exercise 2: Lasers I

1. Write RATE equations for the population of the upper and lower energy levels and the photon density in a situation, in which two-level atoms are excited from the lower level to the upper level by a mechanism having a constant transition probability. The energy of the system would increase continuously, if it is not assumed that part of the photons exit the system. Assume constant probability for the emission of a photon in a time unit. Calculate the photon density in steady state.

2. a) Calculate the photon lifetime in a Fabry-Perot cavity if absorption and other losses are negligible. Use reflectivities of R_1 and R_2 for the mirror facets. b) What is the average time a photon created in the middle of cavity spends in the cavity before emission? c) Calculate the same as in b, but with $R_1 = R_2 = R$.

3. Calculate the separation of the longitudinal modes of a GaAs laser, when the length of the laser is 500 μm, wavelength is 860 nm and the refractive index of the active material is given by $n = 4.18 - \lambda(\mu\text{m}) \cdot 0.63$.

4. The threshold currents for diode lasers having lengths of 250 μm and 500 μm are 1 kA/cm^2 and 0.75 kA/cm^2, respectively. The reflectivity of the mirror facets is 0.65, the cavity losses are 5.5 cm^{-1} and the recombination time constant is 0.5 ns. The thickness of the active layer is 0.2 μm. Calculate the injection density corresponding to the transparency condition of the active material.

5. Threshold current density of a semiconductor laser is J_{th} = 1.35 kA cm^{-2}. A similar structure is used in a superluminescent LED by artificially raising the threshold current. What is the new threshold current density, if the current flows only through half of the area of the diode? Assume the relation of $J = 1\,\text{kA/cm}^2 + g \cdot 5\,\text{A/cm}$ between current density and gain. Refractive index of the active material is 3.5, length of the laser component is 300 μm and the absorption coefficient of the active material at the operation wavelength is α = 3000 cm^{-1}.