Universität Hamburg
Physics Department
Ultrafast Optical Physics II
SoSe 2019

Problem Set 2

Issued: April 26, 2019 Due: May 03, 2019

Instruction: Please write your answer to each problem on separate paper sheet. If you are using programming language to do numerical simulations, attach the original code with your answers.

Problem 2.1: Spontaneous vs. Stimulated Emission (15 points in total)

The ratio between the spontaneous and stimulated emissions is given by:

$$R = \frac{\left.\frac{dN_2}{dt}\right|_{spontaneous}}{\left.\frac{dN_2}{dt}\right|_{stimulated}} = \frac{8\pi \cdot h \cdot \nu^3/c^3}{\rho(\nu)}$$

where h is the Planck's constant, ν is the optical frequency, c is the speed of light, $\rho(\nu)$ is the Planck spectral energy density (i.e. energy per unit volume per unit frequency).

a) Calculate the ratio *R* in thermodynamic equilibrium at *T=300 K* for a MASER with $\nu = 10^{10} Hz$, for a LASER with $\lambda = 1\ \mu m$ and for an X-Ray LASER with a photon energy of 4135.66752 eV. **(10 points)**

b) In the light of the results obtained in a), extract some conclusions. **(5 points)**

Hint: Search through: hyperphysics.phy-astr.gsu.edu you can find the Planck spectral energy density under Blackbody radiation discussion

Problem 2.2: Rate Equations for Two-Level System (15 points in total)

a) Derive the rate equation for the upper and lower energy level, N_1 and N_2 of a non-degenerated two-level system under the influence of an optical pump matching the energy difference of the two levels. **(10 points)**

b) Argue whether it is possible to achieve population inversion in such a system using optical pumping. Support your argument with the results you have obtained above. **(5 points)**