Universität Hamburg
Physics Department
Ultrafast Optical Physics II
SoSe 2020

Problem Set 2

Issued: May 29, 2020 Due: June 05, 2020

Instruction: Please return your electronically to your TA via slack.For this problem set please send to Anna (group A) or Elias (group B). If you are using programming language to do numerical simulations, attach the original code with your answers.

Problem 3.1: Spontaneous vs. Stimulated Emission (15 points in total)

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

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

where h is the Planck's constant, ν is the optical frequency, c is the speed of light, S_ν 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 3.2: 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)**