Ahmedabad University

School of Arts and Sciences

PHY 733 Laser-Matter Interaction

All Programmes
Mid Term Examination 2022 (Winer Semester)

Total Marks = 25 **Time – 3 hours**

Enrolment Number: ..1....
Date: 17-09-2022
No. of printed pages: 2

General Instructions:

Total number of questions: 9
Show all the steps to receive full marks in each question.
Non-scientific calculator is permitted to use in the examination.
Submit both question paper and answer sheet after completion of examination.

1. What is homogeneous and inhomogeneous broadening in the emission spectrum of a laser? (**2 marks**)

2. The rate of spontaneous emission, A_{21}, of a homogeneously broadened laser transition at $10.6\ \mu$m is $A_{21} = 0.34\ s^{-1}$, while its linewidth $\Delta\nu_0$ is $\Delta\nu_0 = 1$ GHz. The degeneracies of lower and upper level are $g_1 = 41$ and $g_2 = 43$, respectively.
   a) Calculate the stimulated emission cross-section at line center.
   b) Calculate the population inversion to obtain a gain coefficient of $5\ m^{-1}$. (**3 marks**)

3. A three-level laser emits a light of wavelength 5500 Å.
   (a) What will be the population of upper level (E_2) to the lower level (E_1) if the optical pumping mechanism is shut off. Assume T=300 K.
   (b) At what temperature for the conditions mentioned above would the ratio of population be half. **(3 marks**)

4. Describe the laser cavity and its different modes. (**2 marks**)

5. If half width of the He Ne laser operating at a wavelength, 6328 Å is 1500 MHz What must be the length of laser cavity to ensure that only one longitudinal mode oscillates? (**3 marks**)

6. What is Q-switching technique and how does a Q-switch laser work? (**3 marks**)

7. Explain the mode locking of a laser? (**3 marks**)

8. Compute the FWHM frequency linewidth for a plane-parallel Fabry-Perot interferometer with two identical mirrors, separated by a distance of 1 cm, with air between the mirrors. Assume mirror reflectivities of $99.99\%, \text{and } 95\%$. Determine the quality factor Q of the cavity for these two cases if the output of a GaAs diode laser operating at 800 nm is transmitted through the interferometer. (**3 marks**)

9. Determine the ABCD matrix for a beam translated a distance d_1, focused through a think lens of focal length f_1, and then translated a distance d_2. (**3 marks**)