Tutorial 6
Polarization and Modern Optics II

- Lasers-Einstein A and B coefficients;
- Ruby and He-Ne lasers;
- Characteristics of laser light-spatial and temporal coherence;
- Focusing of laser beams;
- Three-level scheme for laser operation;
- Holography and simple applications.

Q1:

A parallel beam of light from a He – Ne laser ($\lambda = 630$ nm) is made to fall on a narrow slit of width $0{\cdot}2 \times 10^{-3}$ m. The Fraunhofer diffraction pattern is observed on a screen placed in the focal plane of a convex lens of focal length 0·3 m. Calculate the distance between the (i) first two minima and (ii) first two maxima on the screen. *15*

2013

Q2:

What is the physical significance of Einstein's A-coefficient ? Explain why it is more difficult to achieve Lasing action at X-ray wavelength than at infra-red wavelength. *10*

2014

Q3:

Explain the working principle of a 3-level laser with a specific example. Comment on why the third level is needed. *10*

2014

Q4:

What is the role of an optical resonator in a laser ? Why does one prefer curved mirrors instead of plane mirrors in designing an optical resonator ? *10*

2015

Q5:

Using the concept of Einstein's A and B coefficients for a two-level atomic system under thermal equilibrium, determine the ratio of the number of atoms per unit volume in the two levels experiencing spontaneous and stimulated emission. How does the principle of population inversion lead to the gain mechanism in the active medium of the laser ? *10+10=20*

2015

Q6:

Explain the principle of (i) induced absorption, (ii) spontaneous emission and (iii) stimulated emission. Show that the ratio of Einstein's coefficients is given by

$$\frac{A}{B} = \frac{8\pi h\nu^3}{c^3}$$ 20

2016

Q7:

How is laser light different from ordinary light? Discuss the working principle of ruby laser. What role do chromium ions play in this process? 15

2017

Q8:

Explain the principle and working of He-Ne laser. What is the role of He gas ? Why is it necessary to use narrow tube ? How many longitudinal modes can be excited for an He-Ne laser in a cavity of length 30 cm and having half width of gain profile of laser material 2×10^{-3} nm ? The emission wavelength is 6328 Å. *15*

2018

Q9:

Discuss how population inversion is achieved in Ruby laser.
What is 'laser spiking' ? Why does it occur ? *20*

2019

Q10:

In what way is holography different from conventional photography ? Discuss the salient features of a hologram. What are the requirements for the formation and reading of a hologram ? *20*

2019

Q11:

Briefly discuss the postulates of Einstein to explain stimulated emission. Derive an expression for Einstein's A and B coefficients and show that the ratio of coefficients of spontaneous versus stimulated emission is proportional to the third power of frequency of radiation. Why is it difficult to achieve laser action in higher frequency ranges such as X-rays ?

Can there be a temperature at which the rates of spontaneous and stimulated emission are equal ? Illustrate with wavelength $\lambda = 5000$ Å. *15*

2020

Q12:

In He-Ne laser, what is the function of He gas? Explain the answer with the help of energy level diagram for He-Ne laser. 15

2022

Q13:

What are three and four level pumping schemes ? Explain the lasing action in these with schematic diagrams. *10*

2023

Q14:

How does holography differ from conventional photography ? What are the requirements for the formation and reading of a hologram ? *10*

(Asked in Section B) 2014

Q15.

A light beam of wavelength 600 nm produced by a 20 mW laser source is incident on a plane mirror. Determine :

(i) number of photons per second striking the surface of the mirror.

(ii) force exerted by the light beam on the mirror. *10*

2025

Q16.

Consider a laser system consisting of an active medium placed between a pair of mirrors forming a resonator. Obtain an expression for the threshold population inversion required for the oscillations of laser. *20*

2025

Q17.

For a He – Ne laser system, what will be the magnitude of $\Delta\omega_D$ which represents FWHM of the line shape function $g(\omega)$, if resonant frequency $\omega_0 = 3 \times 10^{15}\ s^{-1}$ and temperature T = 300 K ? *10*

2025