ASSIGNMENT

By

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CSE(AI/ML)

Model Institute of Engineering & Technology (Autonomous)

(Permanently Affiliated to the University of Jammu, Accredited by NAAC with “A” Grade)

Jammu, India

2023

ASSIGNMENT

Subject Code: BSC-102

Due Date: 4 Jan. 2024

Question Number	Course Outcomes	Blooms' Level	Maximum Marks	Marks Obtain
Q1	CO 4	3-6	10	
Q2	CO 5	3-6	10	
Total Marks			20	
Faculty Signature Email:				

Assignment Objectives:

The assignment aims to explore Applied Optics and Laser & Fibre Optics domains. It covers topics such as interference in thin films, Newton's rings theory for determining wavelength and refractive index, Fraunhofer and Fresnel's diffractions, polarization of light, double refraction, Nicol Prism, wave plates, laser principles, fiber optics propagation, numerical aperture, and practical applications.

Assignment Questions:

Q. No.	Questions	BL	CO	Marks	Total Marks
1	How would you apply the principles of Fraunhofer diffraction to determine the relative intensities of successive maxima in a single-slit setup?	3	4	10	10
2	Analyze the concept of spontaneous emission and its significance in the context of quantum mechanics. How does it relate to the decay of excited states in atoms or molecules? Compare and contrast the processes of optical pumping and population inversion in the context of laser physics. How do these mechanisms contribute to achieving a population inversion in a laser medium?	4	5	10	10

Q1. How would you apply the principles of Fraunhofer diffraction to determine the relative intensities of successive maxima in a single-slit setup?

Ans: Fraunhofer diffraction: In this type of diffraction source of light and screen both are at infinite distance from the obstacle. Fraunhofer diffraction requires two convex lenses, one to make the light from the source parallel and the other to focus the diffracted light on the screen. The incident wavefront is plane. The secondary wavelets, which originate from the unblocked portions of the wavefront are in the same phase at every point in the plane of the aperture.

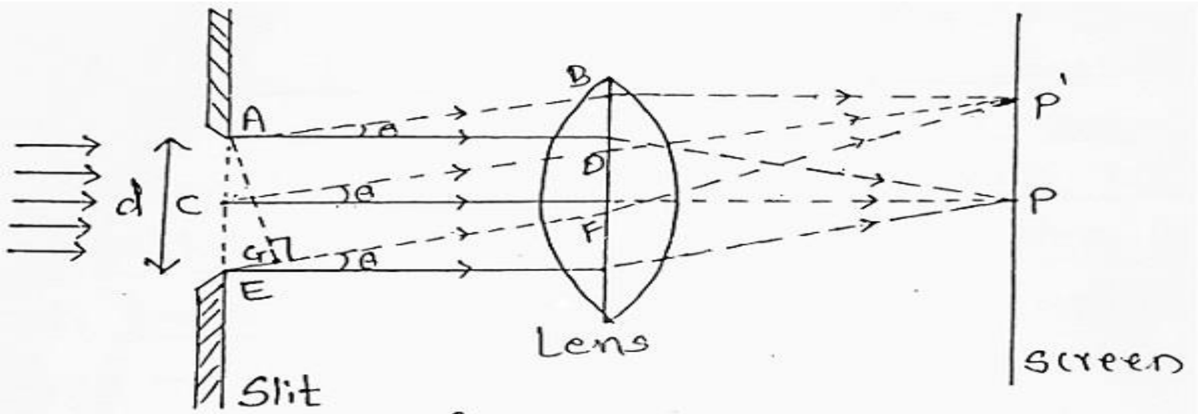


fig. 1

Fraunhofer diffraction occurs when light passes through a single slit or aperture and produces a diffraction pattern characterized by alternating bright and dark fringes on a screen. To determine the relative intensities of successive maxima (bright fringes) in a single-slit setup using Fraunhofer diffraction principles, you can use the formula for the intensity distribution, known as the single-slit diffraction pattern or the diffraction envelope:

$I(\theta)=I0(\sin(\alpha)/\alpha)2$

Where:

•$I(\theta)$ is the intensity at an angle θ from the center of the diffraction pattern.

•$I0$ is the intensity at the center of the pattern.

•α is the angle formed by the point on the screen and the center of the diffraction pattern, given by $\alpha=\pi a\sin(\theta)/ \lambda$.

- a is the width of the slit.
- λ is the wavelength of light.

The equation $I(\theta)=I0(\alpha\sin(\alpha))2$ provides the relative intensities at different angles θ. To determine the relative intensities of successive maxima, you'd evaluate the intensity of each maximum by substituting the corresponding θ values into the equation.

The positions of the maxima are given by the condition for constructive interference in the single-slit diffraction pattern:

$a\sin(\theta m) = m\lambda$

Where:

•θm is the angle of the m-th maximum.

•m is the order of the maximum (1 for the first maximum, 2 for the second, and so on).

•λ is the wavelength of light.

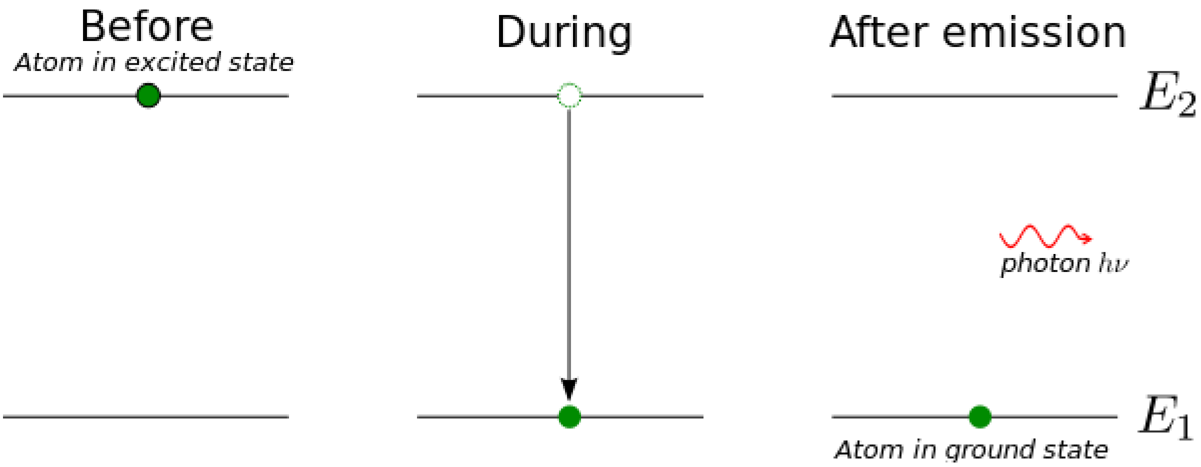
By calculating the angles θ for different orders of maxima (m) using the above equation and then using those angles in the intensity formula $I(\theta)=I0(\alpha\sin(\alpha))2$, you can determine the relative intensities of successive maxima.

Generally, the first maximum (m=1) will have the highest intensity, and the relative intensities of successive maxima decrease as m increases. These intensities can be calculated and compared to establish the relative brightness of different diffraction maxima in a single-slit setup.

Q2. Analyze the concept of spontaneous emission and its significance in the context of quantum mechanics. How does it relate to the decay of excited states in atoms or molecules? Compare and contrast the processes of optical pumping and population inversion in the context of laser physics. How do these mechanisms contribute to achieving a population inversion in a laser medium?

Ans: Spontaneous Emission: This phenomenon occurs when an atom or molecule in an excited state transitions to a lower energy state without any external stimulation. In quantum mechanics, an excited atom or molecule has excess energy due to electronic or vibrational transitions. Eventually, it will return to its ground state by emitting a photon spontaneously. This emission is random in terms of direction, phase, and timing, and it occurs due to the quantized nature of energy levels in quantum systems.

Significance: Spontaneous emission plays a crucial role in various processes like fluorescence, the decay of excited states in atoms or molecules, and the functioning of lasers. It serves as a fundamental process in quantum mechanics and is essential for understanding energy transitions in atomic and molecular systems.



Optical Pumping and Population Inversion:
Optical Pumping: This technique involves using light (photons) to manipulate the populations of energy levels in atoms or molecules. It typically involves applying a strong light source to excite electrons in a material from a lower energy state to a higher one, altering the population distribution. By controlling the light's frequency and direction, it's possible to selectively populate certain energy levels.

Population Inversion: In laser physics, achieving population inversion is critical for laser operation. Population inversion refers to a situation where more atoms or molecules are in an excited state than in the lower energy (ground) state. This state is necessary to create stimulated emission dominant over spontaneous emission, which is essential for amplifying light in a laser.

Contrast between Optical Pumping and Population Inversion:

Optical Pumping is a method used to manipulate the population distribution among energy levels by applying external light sources.

Population Inversion is a state where the number of particles in an excited state surpasses those in the ground state, setting the stage for stimulated emission to dominate over spontaneous emission.

Contribution to Achieving Population Inversion in a Laser Medium:
Optical Pumping contributes to achieving population inversion by selectively increasing the number of particles in the higher energy levels, paving the way for a higher population of excited states.

Population Inversion is essential for laser operation. Once achieved, it sets the conditions necessary for stimulated emission to surpass spontaneous emission, allowing for coherent and amplified light emission, which is the principle behind laser operation.

In summary, spontaneous emission governs the natural decay of excited states, while optical pumping and population inversion techniques are employed to manipulate energy level populations, crucial for achieving laser action by promoting stimulated emission. Achieving and maintaining population inversion is a key factor in the operation of a laser.