Course: Physics-II (6442) Level: BEd (2.5/4-Year) Semester: Spring, 2023

Total Marks: 100

Pass Marks: 50

ASSIGNMENT No. 2

(**Units 5-9**)

Q.1 a.

a. Illustrate the concept of coherent sources and how these sources can be realized. (20)
b. Two slits in double slit experiment have width in ratio. What will be

the

ratio of the amplitudes?

a) Coherent sources refer to two or more light sources that emit waves with a constant phase difference and have a stable relationship with each other. In other words, coherent sources have a fixed phase relationship, which means their waveforms maintain a consistent alignment over time.

To realize coherent sources, the following methods can be employed: 1. Lasers: Lasers are often used to generate coherent light. The emitted light consists of coherent photons that have the same frequency, phase, and polarization. This coherence is achieved by stimulated emission in a laser cavity, which produces a highly focused and coherent beam of light.

- 2. Interference Filters: Interference filters can be used to obtain coherent light by selectively transmitting or reflecting specific wavelengths. These filters are designed to create constructive interference for a particular wavelength, resulting in coherent light.
- 3. Coherence Length Enhancement Techniques: Various techniques can enhance the coherence length of a light source. These include using a single-mode fiber to reduce the spatial and temporal dispersion, employing optical cavities to increase coherence, and employing stabilization methods such as active feedback systems.
- 4. Coherent Fiber Bundles: In some applications, coherent sources can be realized using coherent fiber bundles. These bundles consist of multiple optical fibers that maintain a consistent phase relationship. They are often used in imaging and remote sensing systems.
- b) In the double-slit experiment, the ratio of the amplitudes of the two slits determines the intensity of the resulting interference pattern. Assuming the slits have widths in the given ratio, the ratio of the amplitudes of the wave passing through the two slits will be the square root of the width ratio.

Let's denote the widths of the two slits as w1 and w2, respectively. The ratio of the amplitudes (A1 and A2) can be expressed as:

Amplitude ratio = $\sqrt{(w1/w2)}$

- This is because the intensity (I) of the resulting interference pattern is proportional to the square of the amplitude (A) of the wave:
- $I = |A1 + A2|^{2} = |A1|^{2} + 2|A1||A2|\cos(\Delta \phi) + |A2|^{2}$
- where $\Delta \phi$ represents the phase difference between the waves from the two slits.

Since the intensity is directly related to the width of the slits, the amplitude ratio determines the relative intensities of the two resulting interference patterns. The square root relationship reflects the fact that intensity is proportional to the square of the amplitude.

Therefore, the ratio of the amplitudes is $\sqrt{(w1/w2)}$ for the double-slit experiment with slits of different widths.

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Q.2 Discuss Desperation and Resolving Power of Grating with examples. (20)

The concepts of dispersion and resolving power are important in the study of gratings, which are optical devices that consist of a large number of parallel, equally spaced slits or lines. Gratings are used in various applications, including spectroscopy and optical communication. Let's discuss dispersion and resolving power in the context of gratings, along with examples:

1. Dispersion:

Dispersion refers to the phenomenon where different wavelengths of light are separated or spread out when passing through a grating. It occurs due to the interference and diffraction of light waves passing through the individual slits or lines of the grating. The dispersion pattern created by a grating allows for the analysis and measurement of the spectral components of light.

Example: Suppose white light passes through a diffraction grating. As the light interacts with the grating, it is dispersed into its constituent colors, creating a rainbow-like spectrum. The different wavelengths of light are spread out, allowing for the identification and analysis of individual spectral lines or bands.

2. Resolving Power:

Resolving power refers to the ability of a grating to separate and distinguish closely spaced spectral lines or wavelengths. It is a measure of the grating's ability to resolve small differences in wavelength. The resolving power of a grating depends on the number of slits or lines per unit length and the order of diffraction. Example: Consider a spectrometer that uses a grating to analyze the spectral components of light. A grating with higher resolving power can separate closely spaced spectral lines more effectively than a grating with lower resolving power. This allows for better distinction and measurement of individual wavelengths in the spectrum.

The resolving power of a grating is given by the formula: R = Nm,

where R represents the resolving power, N is the number of slits or lines per unit length, and m is the order of diffraction.

Higher values of N or larger orders of diffraction lead to increased resolving power, enabling the identification of smaller differences in wavelength.

Gratings with high resolving power are particularly useful in applications such as spectroscopy, where the precise measurement and analysis of spectral lines or bands are required. By dispersing light into its constituent wavelengths and having high resolving power, gratings facilitate the detailed study of the electromagnetic spectrum and enable various scientific and technological advancements.

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Q.3 Explain different states of polarization. Also highlight Uses of Polari Meters. (20)

Different States of Polarization:

 Linear Polarization: Linear polarization refers to the polarization state in which the electric field oscillates in a single plane. This can be vertical, horizontal, or at any angle in between. Linearly polarized light can be achieved by passing unpolarized light through a polarizer or by using specialized optical components.

2. Circular Polarization: Circular polarization occurs when the electric field vector of light rotates in a circular pattern as it propagates. Circular polarization can be either clockwise (right-handed) or counterclockwise (left-handed). This state of polarization is commonly observed in applications such as 3D cinema glasses or circularly polarized antennas.

3. Elliptical Polarization: Elliptical polarization is a general term that encompasses polarization states between linear and circular polarization. The electric field vector of light traces an elliptical path during propagation. The shape of the ellipse can vary, ranging from a perfect circle (circular polarization) to an elongated or flattened ellipse (linear polarization).

Uses of Polarimeters: 1. Measurement of Polarization State: Polarimeters are widely used to measure and analyze the state of polarization of light. They can determine the degree of polarization, quantify the orientation of linearly polarized light, and identify the handedness of circularly polarized light.

- Quality Control in Optical Manufacturing: Polarimeters are essential tools for ensuring the quality and performance of optical components. They can verify the desired polarization characteristics of materials, coatings, and devices, such as waveplates, polarizers, and optical filters.
- 3. Material Characterization: Polarimeters are employed in material science and research to investigate the optical properties of various substances. They can determine the birefringence (difference in refractive indices) of materials, such as crystals, liquid crystals, and polymers, which have polarization-dependent properties.

4. Remote Sensing and Imaging: Polarimeters are utilized in remote sensing applications to gather information about the polarization properties of light reflected or scattered by the Earth's surface, atmosphere, or objects. Polarimetric imaging provides additional data for various applications, including environmental monitoring, target detection, and atmospheric studies.

5. Polarization Control in Optical Systems: Polarimeters help calibrate and align optical systems by precisely controlling the state of polarization. They are used in areas such as telecommunications, fiber optics, laser systems, and astronomy to optimize performance, reduce signal degradation, and mitigate unwanted polarization effects.

6. Biological and Medical Applications: Polarimeters have applications in biology and medicine, where the polarization properties of tissues, cells, and fluids can provide valuable diagnostic information. Polarimetry techniques can assist in the detection of structural changes, tissue characterization, and monitoring of biological processes.

polarimeters play a vital role in characterizing, controlling, and utilizing polarization in a wide range of scientific, industrial, and technological applications. They enable the precise measurement and manipulation of polarization, providing valuable insights and facilitating advancements in various fields.

Q.4 State and explain Plank's law of Radiation also Compton effect.

Planck's law of Radiation

Planck's law of radiation is a mathematical relationship that describes the spectral energy distribution of radiation emitted by a blackbody. A blackbody is a hypothetical object that absorbs all radiant energy falling upon it and reflects none.

(20)

The law states that the energy density of radiation emitted by a blackbody per unit wavelength interval is proportional to the frequency of the radiation to the power of 3 and inversely proportional to the absolute temperature of the blackbody.

The law was first proposed by Max Planck in 1900 to explain the observed spectrum of blackbody radiation. Planck's law was a major breakthrough in physics, as it was the first time that a physical property was quantized.



Compton effect

The Compton effect is the scattering of a photon by an electron. The photon loses energy to the electron, and the electron is given a recoil momentum. The amount of energy lost by the photon is proportional to the scattering angle.

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The Compton effect was first observed by Arthur Holly Compton in 1923. The effect was a major confirmation of the wave-particle duality of light.

The equation for the Compton effect is:

Code snippet

 $\lambda' - \lambda = (h/mc)(1 - \cos \theta)$

where:

- assig, λ ' is the wavelength of the scattered photon
 - λ is the wavelength of the incident photon
 - h is Planck's constant
 - m is the mass of the electron
 - c is the speed of light
 - θ is the scattering angle

The Compton effect has a number of important applications. It is used in medical imaging, such as in x-ray crystallography. It is also used in particle physics, such as in the study of elementary particles.

Q.5 Explain Heisenberg uncertainly principle. Discuss its applications in physics. (20)

The Heisenberg uncertainty principle, formulated by the physicist Werner Heisenberg, is a fundamental principle in quantum mechanics. It states that there is a fundamental limit to the precision with which certain pairs of physical properties, such as position and momentum, or energy and time, can be simultaneously known.

Mathematically, the uncertainty principle is expressed as:

 $\Delta x * \Delta p \ge h/2\pi$

where Δx represents the uncertainty in position, Δp represents the uncertainty in momentum, and h is the reduced Planck's constant (approximately 6.626 x 10^-34 J·s or 4.136 x 10^-15 eV·s). The principle states that the product of the uncertainties in position and momentum must be greater than or equal to $h/2\pi$.

objects. In quantum mechanics, particles are described by wavefunctions, which are mathematical functions that contain information about the probability distribution of a particle's properties. The position and momentum of a particle are described by operators in quantum mechanics, and the uncertainty principle arises from the non-commutativity of these operators.

The uncertainty principle has several important implications and applications in physics:

• Limitations on simultaneous measurements: The uncertainty principle implies that it is impossible to precisely measure both the position and momentum of a particle simultaneously. The more accurately one of these properties is known, the less precisely the other can be known.

• Quantum tunneling: The uncertainty principle allows for the phenomenon of quantum tunneling. It states that particles can "tunnel" through energy barriers that would be classically forbidden. This is a crucial concept in understanding phenomena such as radioactive decay and electron tunneling in electronic devices.

• Energy-time uncertainty: The uncertainty principle also applies to the energy and time measurements. It implies that the more precisely the energy of a quantum system is known, the less precisely the time at which it occurred can be determined, and vice versa. This has implications for the measurement and detection of short-lived particles or events.

• Subatomic particle behavior: The uncertainty principle plays a crucial role in understanding the behavior of subatomic particles. It helps explain the probabilistic nature of quantum systems and the wave-like behavior of particles, as well as phenomena like wave-particle duality and the wavefunction collapse upon measurement.

• Quantum mechanics foundation: The uncertainty principle is a fundamental principle of quantum mechanics and is deeply ingrained in its mathematical formalism. It is one of the fundamental principles that distinguish quantum mechanics from classical physics and has shaped our understanding of the microscopic world.

Overall, the Heisenberg uncertainty principle is a foundational concept in quantum mechanics, highlighting the inherent limits to our knowledge and measurements in the microscopic world. Its applications extend to various areas of physics, from explaining the behavior of subatomic particles to enabling technologies such as electron microscopy, quantum computing, and quantum cryptography.

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