

Department of Physics
IIT Kanpur, Semester II, 2016-17

PSO201A: Quantum Physics

Homework # 3

Problem 3.1

Consider beams of radiation of two different wavelengths, λ_1 and λ_2 , respectively. If the intensities of the two beams are the same, what is the ratio of the number of photons per unit cross-sectional area per second of the two beams?

Problem 3.2:

For a photon of wavelength λ_0 , scattering off of an electron of rest mass m_0 , find the relationship between the photon scattering angle θ and the electron scattering angle ϕ .

Problem 3.3:

Find the de-Broglie wavelength λ of a particle of rest mass m_0 moving at relativistic speeds with kinetic energy K . How does this expression change in the non-relativistic limit?

Problem 3.4:

The smallest feature size of an object that can be seen with a microscope is about equal to the wavelength of light used in the microscope. Suppose we need to see an atom with the smallest feature size of 0.1 \AA .

- (a) If an electron microscope is used for the purpose, calculate the minimum energy in KeV that the electrons would need to have.
- (b) If a photon microscope is used for the purpose, calculate the minimum energy in KeV that the photons would need to have.
- (c) which microscope is better?

Problem 3.5:

Consider the following three vectors:

$$|V_1\rangle = \begin{pmatrix} 1 \\ i \\ 0 \end{pmatrix}; \quad |V_2\rangle = \begin{pmatrix} 1 \\ 0 \\ 1 \end{pmatrix}; \quad |V_3\rangle = \begin{pmatrix} 0 \\ i \\ 1 \end{pmatrix} \quad (1)$$

- (a) Are the three vectors linearly independent?
- (b) Are the three vectors mutually orthogonal?
- (c) Starting from the three vectors, derive three orthonormal basis vectors (Hint: Use Gram-Schmidt procedure).
- (d) Can there be another set of three orthonormal basis vectors?