2009

M.Sc.

3rd SEMESTER EXAMINATION

PHYSICS

PAPER—PH-2101

Full Marks : 40

Time : 2 Hours

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

Illustrate the answers wherever necessary.

Module-PH-2101A

(*Relativistic Quantum Mechanics*)

(Marks : 20)

1. Answer any *three* bits : 2×3

   (a) Show that the Dirac Matrices can only be of even order and their eigenvalues are ±1.

   (b) Express Dirac equation in covariant form and express the properties of γ matrices.

(c) Derive the continuity equation for a particle obeying Klein Gordon equation and find expression for current density and probability density.

(d) Obtain expression for current density and probability density in the Dirac formalism.

(e) Show that $\left(\vec{\alpha}.\vec{A}\right)\left(\vec{\alpha}.\vec{B}\right) = \vec{A}.\vec{B} + i\vec{\sigma}^{d}.\left(\vec{A}\times\vec{B}\right)$.

2. Answer any *one* bit : 4

(a) Write Dirac Hamiltonian for an electron in a central potential $V(r)$ and show that the spin-orbit interaction comes automatically in the Dirac equation.

(b) For a Dirac particle moving in a central potential, show that the orbital angular momentum is not a constant of the motion rather the total angular momentum is a constant of the motion.

3. Answer any *one* bit : 10

(a) Obtain the plane wave solution for the spin half particle which obey Dirac equation and comment on the negative energy states.

(b) Obtain the radial equation for the electron in a central potential in the Dirac formalism and hence obtain the energy eigenvalues for the hydrogen atom.

Module-PH-2101B

(*Statistical Mechanics*)

(Marks : 20)

Answer *Q. No. 1* and any *one* from the rest.

1. Answer any *four* bits : $2\frac{1}{2} \times 4$

   (a) Explain quantum mechanical average and ensemble average.

   (b) Why equipartition of energy is not valid for Quantum Harmonic Oscillator.

   (c) If Canonical partition function

   $$Q_N(V,T) = \frac{V^N}{N!}\left(\frac{2\pi m k_B T}{h^2}\right)^{\frac{3N}{2}}$$

   find entropy.

   (d) Systems with finite number of micro-states gives rise to concept of –ve temperature — Explain.

   (e) For non-interacting photons radiation pressure is $\frac{1}{3} \times$ energy density. Why?

   (f) Explain pure state and mixed state in the light of density matrix.

2. (a) Define density matrix. Prove that

$$i\hbar\frac{\partial\hat{\rho}}{\partial t}=\left[\hat{H},\hat{\rho}\right]$$

where $\hat{\rho}$ is the density matrix operator. 1+4

(b) If $\hat{\rho}=\frac{1}{4}\begin{pmatrix}3 & \sqrt{2}-i\\ \sqrt{2}+i & 1\end{pmatrix}$

does it represent pure state of mixed state? What is the state of polarization? 3+2

3. (a) Prove that in grand canonical ensemble relative fluctuation of number of particles $\approx\frac{1}{\sqrt{N}}$. 5

(b) Deduce BE distribution function from grand canonical ensemble. 3

(c) Prove that grand potential $\Omega=-k_BT\,l_n\xi$ where ξ is the grand partition function. 2