

**LOYOLA COLLEGE (AUTONOMOUS), CHENNAI – 600 034**



**M.Sc. DEGREE EXAMINATION – PHYSICS**

**FOURTH SEMESTER – APRIL 2023**

**PPH 4501 – QUANTUM MECHANICS - II**

Date: 29-04-2023

Dept. No.

Max. : 100 Marks

Time: 09:00 AM - 12:00 NOON

**PART – A**

**(10 x 2 = 20 Marks)**

**Q. No**

**Answer ALL questions**

- 1 State the adiabatic theorem with reference to the time dependent perturbation theory.
- 2 What is dipole approximation?
- 3 Two particles come towards each other with speed  $0.8c$  with respect to laboratory. What is their relative speed?
- 4 A beam of particles of half-life  $2 \times 10^{-6}$  s travel in the laboratory with the speed  $0.96$  times the speed of light. How much distance the beam travels before the flux falls to half of its initial flux?
- 5 What is a hole, with reference to a free Dirac particle?
- 6 List any two shortcomings of KG equations.
- 7 Illustrate exchange degeneracy.
- 8 What is symmetry transformation?
- 9 Explain the scattering matrix (S-matrix).
- 10 What do you mean by a normal product?

**PART – B**

**(4 x 7.5 = 30 Marks)**

**Answer any FOUR questions**

- 11 A system in an unperturbed state  $n$  is suddenly subjected to a constant perturbation  $H'(r)$  which exists during time  $0$  to  $t$ . Find the probability for transition from state  $n$  to state  $k$  and show that it varies simple harmonically.
- 12 A  $\pi$  meson of rest mass  $m$  decays into a  $\mu$  meson of mass  $m_\mu$  and a neutron of mass  $m_n$ . Find the total energy of the  $\mu$  meson.
- 13 Give the energy spectrum of a free Dirac particle and explain pair production and pair annihilation.
- 14 Prove that the parity of spherical harmonics  $Y_{l,m}(\theta, \varphi)$  is  $(-1)^l$ .
- 15 Give a thorough description of how a real scalar field is quantized.
- 16 Calculate the percentage contraction of a rod moving with a velocity  $0.8c$  in a direction inclined at

60° to its own length.

**PART – C**

**(4 x 12.5 = 50 Marks)**

**Answer any FOUR questions**

- 17 Discuss time-dependent perturbation theory with reference to sinusoidal perturbation and obtain expression for transition probability.
- 18 Discuss in detail the structure of space time.
- 19 Starting from the basic energy equation derive the *Dirac's relativistic equation* for a free particle.
- 20 (a) Discuss the effect of time reversal in the time-dependent Schrodinger equation.  
(b) If  $\psi_+(r)$  and  $\psi_-(r)$  are the Eigen functions of the parity operator belonging to even and odd eigenstates, show that they are orthogonal. (6.5+6)
- 21 Describe the quantization of a complex scalar field.
- 22 (a) Discuss the work-energy theorem in relativity. (b) A photon of energy  $E_0$  bounces off an electron at rest. Find the energy  $E$  of the outgoing photon, as a function of the scattering angle  $\theta$ . (4.5+8)

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