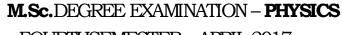
LOYOLA COLLEGE (AUTONOMOUS), CHENNAI – 600 034



FOURTHSEMESTER - APRIL 2017

PH 4810- QUANTUM MECHANICS - II

Date: 18-04-2017 09:00-12:00 Dept. No.

Max.: 100 Marks

PART A

 $10 \ge 2 = 20$ marks

Answer ALL questions:

- 1. Write a note on Rabi cycle.
- 2. Write the condition under which stimulated emission equals spontaneous emission.
- 3. Write down the expression for the kinetic energy of a relativistic particle and verify that it reduces to $\frac{1}{2}$ mv² when the speed of the particle v \ll c, the speed of light
- 4. State work-energy theorem.
- 5. Write down the Dirac matrices in terms of the (2x2) Pauli spin matrices and unit matrix
- 6. Write a short note on Lamb Shift.
- 7. Show that the Eigen values of a particle exchange operator are ± 1 .
- 8. Distinguish between parahelium and orthohelium.
- 9. What do you understand by a field?
- 10. Write a short note on Mollar scattering.

PART B

Answer ANY FOUR questions

4x7.5=30 marks

11. A system in an unperturbed state n is suddenly subjected to a constant perturbation H(r) which exists during time 0 t. Find the probability for transition from state n to state k and show it varies simple harmonically with,

Angular frequency =
$$\frac{E_{k-}E_n}{2\hbar}$$
 and Amplitude = $4 \frac{|H'_{kn}|^2}{(E_k - E_n)^2}$

- 12. (a) If a particle's kinetic energy is n times its rest energy, what is its velocity? (b) Two events occurring at the same place in an inertial frame are separated by a time interval of 6 secs. What is the spatial separation between these two events in an inertial frame in which the events are separated by time interval of 4 secs. (4+3.5)
- 13. For a Dirac particle moving in a central potential, show that the orbital angular momentum is not a constant of motion.
- 14. The base vectors of a representation are $\begin{pmatrix} 1 \\ 0 \end{pmatrix}$ and $\begin{pmatrix} 0 \\ 1 \end{pmatrix}$. Construct a transformation matrix U for transformation to another representation having the base vectors

$$\begin{pmatrix} \frac{1}{\sqrt{2}} \\ i \\ \sqrt{2} \\ \frac{-i}{\sqrt{2}} \end{pmatrix}$$
 Also show that the matrix is unitary

- 15. Describe in detail the quantization of a real scalar field.
- 16. Explain in detail the structure of Spacetime.

PART-C

Answer any FOUR questions:

4 x 12.5 = 50 marks

- 17. Discuss the time dependent perturbation theory with reference to sinusoidal perturbation and obtain an expression for transition probability.
- 18. (a) A pion at rest decays into a muon and a neutrino. Find the energy of the outgoing muon in terms of the two masses, mπ and mµ (assume mv=0). Also find the velocity of the outgoing muon.

(b) Two lumps of clay, each of rest mass (m), collide head-on at $\frac{3}{5}$ c if they stick together, what is the mass (M) of the composite lump? (8+4.5)

19. If $\vec{\alpha}$ and β are Dirac matrices prove that

i.
$$\alpha_{x} = \frac{1}{2} [\alpha_{x} \alpha_{y}, \alpha_{y}]$$

ii.
$$\alpha_x \alpha_y \alpha_z = \frac{1}{2} [\alpha_x \alpha_y \alpha_z \beta, \beta]$$

- iii. Trace $(\vec{\alpha}.B)(\vec{\alpha}.C) = 4$ B. C [3+3+6.5]
- 20.(a) Explain how symmetric and antisymmetric wave functions are constructed from unsymmetrized solution of the Schrodinger equation of a system of indistinguishable particles. (b) If $\psi_{+}(r)$ and $\psi_{-}(r)$ are the Eigen functions of the parity operator belonging to even and odd Eigen states, show that they are orthogonal. [6+6.5]
- 21. What do you understand by Feynman's diagram? What are the rules followed in

these diagrams?

22. Klein-Gordon equation is considered as a relativistic equation for a system of arbitrary number of particles and their antiparticles. Why?

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