Birla Institute of Technology and Science - Pilani, Pilani Campus

Session 2017-18 (Semester - I)

Comprehensive Examination (Closed Book)

Course: Particle Physics (PHYF413)

Date: 09/12/2017

Time: 90 Mints. Max. Marks: 40

Q1: A pion traveling at speed v decays into muon and neutrino, $\pi^- \rightarrow \mu^- + \bar{\nu}_\mu$. If the neutrino emerges at right angle from the original direction of the pion, at what angle does the muon come off ? Masses of pion and muon are m_π, $m_{\mu-}$, respectively. [8]

Q2: A free electron having four momentum p^μ is described by a four component wave function $\psi = u(\vec{p})e^{-p.x}$. Above electron satisfies the Dirac equation, $(\gamma_\mu p^\mu - m)\psi = 0$. Write an equation describing an electron in an electromagnetic field A^μ. Derive an expression for the T_{fi} and identify the Dirac current for the electron. [8]

Q3: Using the expression for Dirac current obtained in Q2, obtain an expression for T_{fi} for the interaction of $e{-}\mu{-} \rightarrow e{-}\mu{-}$. Thus define Lorentz invariant amplitude $-iM$. Also draw the relevant Feynman diagram with appropriate terms (external lines, vertex factors and propagator) on the different components of the diagram. [6]

Q4: Write invariant amplitude for the pair annihilation and Compton scattering processes: $e^-e^+ \rightarrow \gamma\gamma$, $\gamma e^- \rightarrow \gamma e^-$. [3+3]

Q5: An electron with spin interacts with A^μ not only via its charge but also via its magnetic moment. Above statement is called Gordon decomposition and stated as follows:

$\bar{u}_f\gamma^\mu u_i = \frac{1}{2m}\bar{u}_f[(p_f + p_i)^\mu + i\sigma^{\mu\nu}(p_f - p_i)_\nu]u_i$.

Prove the above result using the Dirac equation for spinors $\bar{u}_f$ and u_i. p_f and p_i are final and initial four momenta of electron with mass m. [Given, $\sigma^{\mu\nu} = \frac{i}{2}(\gamma^\mu\gamma^\nu - \gamma^\nu\gamma^\mu)$][6]

Q6: Prove the following:

(i) $\gamma_\mu \not{a}\not{b}\gamma^\mu = 4\,a.b$ (ii) $\gamma_\mu \not{a}\not{b}\not{c}\gamma^\mu = -2\not{c}\not{b}\not{a}$. [3+3]

** Best of Luck **