Problem Sheet 1

3C24

February 23, 2001

1. Calculate the range of the forces transmitted by gauge bosons of mass:[3]

   (i) m = 100 GeV

   (ii) m = 100 MeV

   (iii) m = 5 Gev (hypothetical)

   Calculate the equivalent energy of the distance:[3]

   (i) 10^{-15}m (1fm)

   (ii) 10^{-18}m

   (iii) 10^{-9}m (1nm)

2. Draw Feynman Diagrams for the following processes and show that the quantum numbers Baryon number, Lepton (flavour) number, electric charge and colour are conserved at the vertices and identify which Gauge Boson is being exchanged:

   (i) $\mu^-\mu^- \to \mu^-\mu^-$[6]

   (ii) $e^-e^+ \to e^-e^+$[6]

   (iii) $e^+\mu^+ \to e^+\mu^+$[6]

   (iv) $e^-\nu_e \to \nu_e e^-$[6]

3. (i) Derive the expression for the Invariant Amplitude from the premise that Perturbation Theory is valid.[5]

   (ii) At a distance scale of 10^{-18}m, compare the relative Invariant Amplitudes for Strong (colour), Weak and Electromagnetic Forces. (Ignore the energy dependence of the coupling strength).[2+3]

   (iii) At a momentum transfer of 10GeV, compare the relative Invariant Amplitudes for Strong (pion), Weak and Electromagnetic Forces. (Ignore the energy dependence of the coupling strength).[3]

4. (i) Write down the expression relating the Invariant Amplitude to the cross section and explain why we are interested in this relation.[1+4]

   (ii) Explain the concept of **density of states**.[3]