Introduction to Nuclear and Particle Physics
Final Exam
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December 10, 2007

1. Show that Klein-Gordon equation suffers from the presence of negative energy states and negative probability densities.

2. Show that from Dirac equation probability density ρ is guaranteed to be positive for both positive and negative energy solutions.

3. Show that orbital angular momentum L and spin operator Σ do not commute with hamiltonian while the total angular momentum operator

$J = L + \frac{1}{2}\Sigma$

commutes and therefore is conserved.

4. Classify the following decays as Strong, Electromagnetic or Weak:

a) $B^- \to D^0 + \pi^-$

b) $Z^0 \to \nu_\mu + \bar{\nu}_\mu$

c) $\Delta^{++} \to p + \pi^+$

d) $\Sigma^0 \to \Lambda^0 + \gamma$

e) $\Omega^- \to \Lambda^0 + K^-$

f) $\rho^0 \to \pi^+ + \pi^-$

5. Given the CP eigenstates K_1 and K_2 are

$K_1 = \frac{1}{\sqrt{2}}(K^0 + \bar{K}^0)$

$K_2 = \frac{1}{\sqrt{2}}(K^0 - \bar{K}^0)$

express K^0 and $\bar{K}^0$ in terms of K_1 and K_2.

A beam of K^0 is allowed to decay in vacuum. At distance downstream corresponding to 20 K_1 lifetimes there is a target which absorbs 10% of the K^0 incident on it. If the cross section for $\bar{K}^0$ is 3 times that for K^0, calculate the relative amplitudes of K_1 and K_2 in the beam a) at the start, b) just before the target and c) just after the target.

6. Draw Feynman diagrams for the following decay modes of the D^0 meson.

a) $D^0 \rightarrow K^- + \pi^+$

b) $D^0 \rightarrow \pi^- + \pi^+$

c) $D^0 \rightarrow K^+ + \pi^-$

Estimate the relative decay amplitudes for the three decays.

7. Using the values in the CKM Matrix calculate the branching ratios of W^+ into all quark antiquark and lepton pairs i.e. $u\bar{d}$, $c\bar{d}$, $u\bar{s}$,...,$e^+\nu_e$,... etc. The sum of branching ratios should be one. (Hint: The branching ratio $W \rightarrow$ hadrons has been measured to be about 67%).

8. Write brief accounts of the three of the following:

a) electromagnetic showers and their detection;

b) deep-inelastic $e^{\pm}p$ scattering;

c) non-calorimetric particle identification techniques;

d) experimental tests of electroweak Standard Model;

e) the evidence for a finite neutrino mass.