Physics 570 Homework 4

Due Wednesday, October 4, 2017

Problem 1 (20 points)

A neutral meson X has $J = 1$ (J is the total angular momentum) and a neutral meson Y has $J = 2$. Both X and Y can decay to $\pi^+\pi^-$ by strong interaction. What are the C and P parities of X and Y? Is $X \to \pi^0 + \gamma$ decay allowed by electromagnetic interaction? Is $Y \to \pi^0 + \gamma$ decay allowed by electromagnetic interaction?

Problem 2 (20 points)

The dominant decays of the η meson are

$$\eta \to 2\gamma \ (39\%), \ \ \eta \to 3\pi \ (56\%), \ \ \eta \to \pi\pi\gamma \ (5\%)$$

and it's classified as a "stable" particle, so evidently none of these is a purely strong interaction. Offhand, this seems odd, since at 549 MeV/c^2 the η has plenty of mass to decay strongly into 2π or 3π.

a) Explain why the 2π mode is forbidden, for both strong and electromagnetic interactions.

b) Explain why the 3π mode is forbidden as a strong interaction, but allowed as an electromagnetic decay.

Problem 3 (15 points)

You are planning for a new experiment to search for an exotic meson which can not be described as a quark-antiquark bound state. Which of the following decay channel(s) for X would prove unambiguously that X is indeed an exotic meson? Assume that these decays proceed via strong interaction.

a) $X \to \pi^+ + \pi^0$

b) $X \to K^- + \pi^+ + K^-$

c) $X \to \pi^+ + \pi^0 + \pi^+$

Problem 4 (25 points)

Assuming isospin conservation, are the following reactions allowed?

(a) $d + d \rightarrow {}^4He + \omega$

(b) $d + d \rightarrow {}^4He + \eta$

(c) $d + d \rightarrow {}^4He + \rho^\circ$

(d) $p + d \rightarrow {}^3He + \eta$

(e) $p + p \rightarrow d + \rho^+$

Problem 5 (20 points)

Find the effect of space-inversion (P) and time-reversal (T) operations on the following quantities:

a) position ($\mathbf{r}$)

b) momentum ($\mathbf{p}$)

c) spin (σ)

d) electric field ($\mathbf{E}$)

e) magnetic field ($\mathbf{B}$)

f) magnetic dipole moment ($\sigma \cdot \mathbf{B}$)

g) electric dipole moment ($\sigma \cdot \mathbf{E}$)

h) spin correlation ($\sigma_\mathbf{1} \cdot \sigma_\mathbf{2}$)

i) longitudinal polarization ($\sigma \cdot \mathbf{p}$)

j) transverse polarization ($\sigma \cdot (\mathbf{p_1} \times \mathbf{p_2})$)