

University of Minnesota
School of Physics and Astronomy

2025 Fall Physics 8901
Elementary Particle Physics I
Assignment Solution

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Problem Set 2 due 9:30 AM, Monday, September 29th

Question 1

The $\tau - \theta$ Puzzle

In the 1950's, two particles τ , θ were discovered with the same mass and lifetime that decayed differently. At the time, physicists believed that parity was conserved in all interactions.

- (a) Consider the decay $\theta \rightarrow \pi + \pi^0$. Assuming parity invariance and zero for the spin of θ , find the parity of θ .
- (b) Now consider the decay process $\tau \rightarrow \pi^+ \pi^+ \pi^-$. (This is an old symbol for the K meson.) Let l be the orbital angular momentum of $\pi^+ \pi^+$ and l' the orbital angular momentum of π^- relative to the center-of-mass of $\pi^+ \pi^+$. Assuming parity invariance and the spin of τ equal to zero, find its parity.
- (c) What resolved the $\tau - \theta$ puzzle?

Question 2

List all applicable conservation laws that are or would be violated in the following decays:

1. $\rho^0 \rightarrow \pi^0 \pi^0$
2. $\rho \rightarrow \gamma \gamma$
3. $K^+ \rightarrow \pi^+ \pi^0$
4. $\pi^0 \rightarrow 5\gamma$

(Look up the corresponding parities from the Particle Data Group at <http://pdg.lbl.gov>.)

Question 3

List all states (J^{PC}) with total spin $J = 0, 1, 2$ and P, C parities that cannot be realized as a fermion-antifermion system (i.e., as e^+e^- or quark-antiquark). (Hypothetical particles with such combinations of quantum numbers are called exotic, and are being sought for in experiments, so far unsuccessfully.)

Question 4

State which of the following combinations can or cannot exist in a state of isospin $I = 1$, and give the reasons:

1. $\pi^0\pi^0$

2. $\pi^+\pi^-$

3. $\Sigma^0\pi^0$

4. $\Lambda\pi^0$