

Physics 780.02 Homework Set 2Due 2/15/2010

- 1) Show that:
 - a) Maxwell's equation $\nabla \cdot \mathbf{B} = 0$ is Lorentz invariant.
 - b) Maxwell's equations are gauge invariant.
- 2) The Σ^{*0} can decay into $\Sigma^+ + \pi^-$, $\Sigma^0 + \pi^0$, or $\Sigma^- + \pi^+$. Suppose you had 100 such disintegrations how many of each type (on average) would you expect to see? Hint: use isospin.
- 3) The reaction neutron+anti-neutron $\rightarrow \pi^0\pi^0$ proceeds at rest via S-states. Explain why this reaction cannot occur via the strong interaction.
- 4) Use the available experimental data to calculate $|\eta_{+-}|$ and $|\eta_{00}|$. Assuming that $\varepsilon' \ll \varepsilon$ show that:

$$\left| \frac{\eta_{+-}}{\eta_{00}} \right|^2 \approx 1 + 6 \operatorname{Re} \left(\frac{\varepsilon'}{\varepsilon} \right)$$

and use this approximation to calculate a value for $\operatorname{Re}(\varepsilon'/\varepsilon)$.

All the necessary data can be found in the "Review of Particle Physics" available on the WEB (<http://pdg.lbl.gov/>).

- 5) Using the notes from lecture as a guide (or do it your own favorite way) show that:

$$\left| \langle \bar{K}^0 | K^0(t) \rangle \right|^2 = \frac{1}{4} \left(e^{-\frac{t}{\tau_1}} + e^{-\frac{t}{\tau_2}} - 2e^{-\frac{t}{2} \left(\frac{1}{\tau_1} + \frac{1}{\tau_2} \right)} \cos \left(\frac{t}{\hbar} (m_2 - m_1) \right) \right)$$

Plot this function (let the x-axis be t/τ_1) for $0 < t < 10\tau_1$ assuming:

- a) $\frac{(m_2 - m_1)}{\hbar} \tau_1 = 0.5$
- b) $\frac{(m_2 - m_1)}{\hbar} \tau_1 = 5$
- c) $\frac{(m_2 - m_1)}{\hbar} \tau_1 = 0.05$

Note: Assume that CP is conserved and that τ_1 is the lifetime of the K_1 and τ_2 is the lifetime of the K_2 .

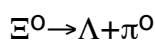
Briefly describe how one could measure (or observe) this oscillation process.

- 6) Verify equations 6.41 and 6.43 (page 166) of Martin and Shaw.

- 7) The paper that describes the discovery of the Ω^- claims the reaction is:



with $\Omega^- \rightarrow \Xi^0 + \pi^-$



$$\Lambda \rightarrow p + \pi^-$$

$$\pi^0 \rightarrow \gamma_1 \gamma_2$$

$$\gamma_1 \text{ and } \gamma_2 \rightarrow e^+ e^-$$

Use the picture in the notes of the event and the (actual) data given in the table of “measured quantities” below to calculate:

- the “mass” (actually, the invariant mass of the $p\pi$ combination) of the Λ
- the “mass” of the π^0
- the “mass” of the Ξ^0
- the “mass” of the Ω^- .

For each case how close (in MeV) does the calculation come to the accepted mass value (i.e. the PDG value)?

Measured Quantities			
Track	Azimuth (deg.)	Dip (deg.)	Momentum (MeV/c)
1	4.2	1.1	4890
2	6.9	3.3	501
3	14.5	-1.5	unmeasured
4	79.5	-2.7	281
5	344.5	-12.0	256
6	9.6	-2.5	1500
7	357	3.9	82
8	63.3	-2.4	177

Note: this is the usual spherical coordinate system with $\theta = 90^\circ - \text{Dip}$.