Assignment 6

Due Tuesday, October 17

Problem 1
In a bubble chamber experiment with a $K^-$ beam, a sample of events of the reaction $K^- + p \rightarrow \Lambda^0 + \pi^+ + \pi^-$ is selected. A resonance is detected both in the $\Lambda^0 \pi^+$ and in the $\Lambda^0 \pi^-$ mass distributions. In both, the mass of the resonance is $M = 1385$ MeV and its width $\Gamma = 50$ MeV. It is called the $\Sigma(1385)$.

(a) What are the strangeness, hypercharge, isospin, and isospin third component of the resonance $\Lambda^0 \pi^+$?

(b) If the study of the angular distribution establishes that the orbital angular momentum of the $\Lambda^0 \pi$ system is $L = 1$, what are the possible spin-parity values $J^P$?

Hint: From the width you can conclude which interaction is responsible for the decay and therefore which conservation laws apply.

Problem 2
The $\rho^0$ has spin 1; the $f^0$ meson has spin 2. Both decay into $\pi^+ \pi^-$. Is the $\pi^0 \gamma$ decay forbidden for one of them, for both, or for none?

Hint: From the $\pi^+ \pi^-$ decay mode you can deduce the charge conjugation eigenvalues of the $\rho^0$ and $f^0$ mesons.

Problem 3
Calculate the branching ratio $\Gamma (K^{*+} \rightarrow K^0 + \pi^+) / \Gamma (K^{*+} \rightarrow K^+ + \pi^0)$ assuming, in turn, that the isospin of the $K^*$ is $I_{K^*} = 1/2$ or $I_{K^*} = 3/2$.

Problem 4
Establish the possible total isospin values of the $2\pi^0$ system.

Hint: Consider the Clebsch-Gordan coefficients for all possible values of $I$. 
**Problem 5**

Knowing that the spin and parity of the deuteron are $J^p = 1^+$, give its possible states in spectroscopic notation.

**Problem 6**

Answer the following questions on the paper by G.R. Kalbfleisch *et al.*, “Observation of a Nonstrange Meson of Mass 959 MeV,” *Phys. Rev. Lett.* 12 (1964) 527 that was distributed in class.

1. Why did the authors conclude that the particle was a meson and nonstrange?

2. The particle was found as a peak in the invariant mass spectrum of five pions. The paper claims that the new meson decays into $\eta + \pi^+ + \pi^-$, at least some of the time. What is this claim based on?

3. What is the evidence that this particle is a scalar (as opposed to a vector)?

4. The authors also conclude that the isospin is $I = 0$. (In the paper the symbol $T$ is used for isospin). Why did they think that?

5. There is a caveat in the conclusion No. 4 above. What is it?