PHYS 316 Homework 6

Due: 25 February 2008

Problem 1.

(i) How is the magnetic moment of a particle, p, related to that of its antiparticle, $\overline{p}$? [*Hint*: What happens when you apply charge conjugation to the magnetic moment?]

(ii) Why do we expect the dipole moment of the pseudo-scalar mesons to be zero?

(iii) Write down the flavor/spin wave function for the ρ^0. Calculate the magnetic moment we expect for the ρ^0. How does this compare to experiment?

Problem 2. In the previous homework we considered the case of *colorless quarks* and wrote down the totally antisymmetric states for $|p\uparrow\rangle$ and $|n\uparrow\rangle$.

(i) Using these states calculate the masses of the proton and neutron. Compare them, in magnitude and ratio, to the data.

(ii) Using these states calculate the dipole moments of the proton and neutron. Compare them, in sign, magnitude, and ratio, to the data.

(iii) What do you deduce about these antisymmetric states?

Problem 3. Griffiths 5.22. [*Note*: The coefficients for the η given in the hint are not correct. Look at the quark content to figure them out.]

Problem 4. Griffiths 5.23. [*Note*: The F is now known as the D_s. Similarly F^* is now called the D_s^*. More of the "beautiful" mesons have been observed than claimed in the problem. Compare your results to all the mesons that have been measured.]

Problem 5. Griffiths 3.4.

Problem 6. A particle is traveling with speed $3/5c$ in the x-direction.

(i) Write down the four-velocity, v^μ, for this particle.

(ii) Write down the four-velocity of the particle as seen in a frame moving with speed $u = 2/5c$ along the x-direction.

Problem 7. Relativity and Maxwell's theory are closely linked. We can write Maxwell's theory in covariant form using the four-potential $A^\mu = (\Phi/c, \mathbf{A})$. The field strength tensor is then defined by $F^{\mu\nu} \equiv \partial^\mu A^\nu - \partial^\nu A^\mu$ where

$$\partial_\mu = \left(\frac{\partial}{c\partial t}, \boldsymbol{\nabla}\right).$$

(i) Notice that the derivative operator is naturally covariant, ∂_μ. Write the contravariant four-vector, ∂^μ.

(ii) Calculate the field strength tensor, $F^{\mu\nu}$, in terms of the components of $\mathbf{E}$ and $\mathbf{B}$ where $\mathbf{E} = -\boldsymbol{\nabla}\Phi - \partial\mathbf{A}/\partial t$ and $\mathbf{B} = \boldsymbol{\nabla} \times \mathbf{A}$.

(iii) Of significant importance in fundamental theories are Lorentz invariant quantities (Lorentz scalars). Calculate the scalar $F^{\mu\nu}F_{\mu\nu}$ in terms of $\mathbf{E}$ and $\mathbf{B}$.