KING FAHD UNIVERSITY OF PETROLEUM AND MINERALS
Particle Physics (Phys. 441)

Assignment # 4
Due to Monday December 13, 2004

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1. Use Clebsch-Gordan table to find all spin states of three quarks. (15 pts.)

2. Use Baryon mass formula; namely

$$M \;=\; m_1 + m_2 + m_3 + 250 m_u^2(\text{MeV}) \left[\frac{\mathbf{S_1}.\mathbf{S_2}}{m_1 m_2} + \frac{\mathbf{S_1}.\mathbf{S_3}}{m_1 m_3} + \frac{\mathbf{S_2}.\mathbf{S_3}}{m_2 m_3}\right],$$

   to obtain the masses of the particles in the baryon octet. Compare these masses with the experimental values. (30 pts.)

3. Prove that the quark model relations for the magnetic moments of the $\rho^{\pm}$ mesons are

$$\mu_{\rho^+} = -\mu_{\rho^-} = \mu_P \;,$$

   where μ_P is the magnetic moment of the proton. (20 pts.)

4. Baryons are fermions and their wave functions should be totally antisymmetric under the exchange of any two particles. One way to achieve this is to invoke the color principle. Another way is to forget about color and construct a totally antisymmetric spin-flavor wave function. Consider for example particles in the baryon octet. The totally antisymmetric proton wave function, for example, is given by

$$|\, P \uparrow\rangle = \frac{1}{\sqrt{2}} \left[P_A\, \chi^{1/2}_{MS} - P_S\, \chi^{1/2}_{MA}\right],$$

   (a) Write the explicit form of the above wave function. (10 pts.)

   (b) Obtain the explicit wave function of the neutron, that is find $|n \uparrow\rangle$. (10 pts.)

   (c) Find the ratio of the neutron magnetic moment to the proton magnetic moment using the above wave functions. (10 pts.)

   (d) Compare the calculated ratio with the experimental one. What do you conclude from the comparison? (5 pts.)