

PY 451: Quantum Physics I Problem Set 12

Due date: Thursday, April 30 2009 by 5pm in the graders' box

- (Griffiths 4.35) Quarks carry spin $1/2$. Three quarks bind together to make a baryon (such as the proton or neutron); two quarks (actually a quark and anti-quark) bind to make a meson (such as the pion or kaon). Assume that the quarks are in their ground states so that the orbital angular momentum is zero.
 - What spin quantum numbers are possible for baryons?
 - What spin quantum numbers are possible for mesons?
- By following the steps outlined in lecture, determine by detailed calculation the spin matrices S_x , S_y , and S_z for a spin-1 particle. For the ambitious students, note that this same calculation can be extended to a particle with arbitrary spin quantum number s . You are invited to try this latter calculation; the answer is given in problem 4.53 of Griffiths.
- (part of Griffiths 4.36) Two particles with spin quantum numbers 1 and 2 are at rest in a configuration such that the total spin quantum number is 3 and the z -component of the total spin is \hbar . If you measured the z -component of the angular momentum of the spin-2 particle, what values might you get, and what is the probability of each value?
- (text 10-14) A spin-1 particle moves in a central potential of the form

$$V(r) = v_1(r) + \frac{\mathbf{S} \cdot \mathbf{L}}{\hbar^2} V_2(r) + \frac{(\mathbf{S} \cdot \mathbf{L})^2}{\hbar^4} V_3(r)$$

Define $\mathbf{J} = \mathbf{L} + \mathbf{S}$ as the total angular momentum of the system, and \mathbf{L} as the orbital angular momentum. What are the values of $V(r)$ in the states $J = L + 1$, $J = L$, and $J = L - 1$?