

Physics 325 Assignment 1
Due Tuesday 1/20/09

1. C&G problem 1.3(b)

2. a) Two protons in a nucleus separated by a distance r influence each other through the electromagnetic as well as the weak force (the gravitational force is negligible, and we'll look at the strong force in part b). The electromagnetic force falls off like $\frac{1}{r}$, and the weak force falls off like $\frac{e^{-\kappa r}}{r}$, with $\kappa = M_Z c^2 / \hbar c$. Plot (by hand or with some appropriate software) these two functions on the same graph. Choose a distance scale that shows clearly that the scale of the weak force is much less than a fm. Be sure to label the axes appropriately.

b) Sometimes the strong force between protons (or neutrons) is modeled by an interaction in which a particle called a pi meson is exchanged. Look up the mass of the neutral pi meson (π^0) and make a graph of $\frac{e^{-\kappa r}}{r}$, assuming that the relevant mass in this case is the π^0 mass. Choose a scale for your graph that shows the range of the strong force clearly. It should be on the order of a fm—is it?

Hint: The Particle Data Group Live website (link on the course web page, or Google it) has data including masses for every known particle. The pi meson is a “light unflavored meson.” (“light”=not very massive; “unflavored”=containing only u and d quarks, “meson”=a hadron made of a quark and an antiquark)

3. Use the concept of conservation of lepton number to fill in the missing particles in the following processes.

a) $\mu^+ \rightarrow e^+ + \underline{\hspace{1cm}} + \underline{\hspace{1cm}}$

b) $\tau^+ \rightarrow \mu^+ + \underline{\hspace{1cm}} + \underline{\hspace{1cm}}$

c) $\tau^+ \rightarrow \underline{\hspace{1cm}} + \nu_e + \underline{\hspace{1cm}}$

4. a) Look up the half-life of ^{32}P , and use it to find the probability of a given ^{32}P nucleus decaying during a given 24-hour period.

b) At $t=0$ a sample contains 600 atoms of ^{32}P . How many atoms of ^{32}P would you expect to remain in the sample 30 days later?

5. The carbon in living organisms contains about 1.3 atoms of ^{14}C for every 10^{12} atoms of all kinds of carbon. a) How many decays per minute would one expect from 7.0 g of carbon taken from a living tree?

b) If 7.0 g of carbon is extracted from a piece of wood found in an archaeological dig, and it's measured to produce 10 decays per minute, about how old is the wood?

c) In a bad movie whose title I've forgotten, the characters claimed that they were going to carbon date some gold bars they found to see if they were lost treasure from the American Civil War. Critique this statement.