Particle Physics, Autumn 2014 CMI

Problem set 2

Due by beginning of lecture on Monday Oct 13, 2014

Pions and nucleons

1. ⟨**5**⟩ The $1/E^2$ decay of scattering cross sections applies to scattering of point-like particles. It is found that at high energies, the cross section for $\pi^+ p$ scattering tends to a constant around 30 millibarns. Use this to estimate the sum of the radii $R_\pi + R_p$. Hint: At high energies, a classical approximation to the collision cross section should be valid. What is this classical cross section in terms of R_π and R_p if you assume that the strong interaction has a very short (essentially zero) range?

2. ⟨**12**⟩ Find the Clebsch-Gordan coefficients for addition of $j = 1$ and $j = \frac{1}{2}$. This will be useful to understand pion nucleon scattering. The combination decomposes as $\frac{3}{2} \oplus \frac{1}{2}$. The uncoupled basis is ordered as

$$|1\rangle|\uparrow\rangle,\ |1\rangle|\downarrow\rangle,\ |0\rangle|\uparrow\rangle,\ |0\rangle|\downarrow\rangle,\ |-1\rangle|\uparrow\rangle,\ |-1\rangle|\downarrow\rangle. \tag{1}$$

   and the coupled basis is ordered with decreasing $m = m_1 + m_2$

$$|3/2, 3/2\rangle,\ |3/2, 1/2\rangle,\ |1/2, 1/2\rangle,\ |3/2, -1/2\rangle,\ |1/2, -1/2\rangle,\ |3/2, -3/2\rangle. \tag{2}$$

   Find the matrix C of CG coefficients by choosing phases in a suitable way so that it is a symmetric matrix. Verify that C is an orthogonal matrix.