PHYSICS 474: Introduction to Particle Physics

Homework 12 **Due:** noon Friday, April 27, 2018

1. **Color Factors:**

   (a) [15 points] Calculate the $q\bar{q}$ color factor

   $$f = \frac{1}{4}(c_3^\dagger \lambda^\alpha c_1)(c_2^\dagger \lambda^\alpha c_4) \tag{1}$$

   for the *octet* configuration using the states (i) $b\bar{g}$, (ii) $r\bar{g}$, (iii) $(r\bar{r} - b\bar{b})/\sqrt{2}$, and (iv) $(r\bar{r} + b\bar{b} - 2g\bar{g})/\sqrt{6}$. What do you infer from this exercise?

   (b) [10 points] Consider the $q\bar{q}$ scattering with the same quark flavors, e.g. $u\bar{u} \to u\bar{u}$. In this case, we also have a t-channel diagram, in addition to the s-channel diagram discussed in class. Show that the color factor f in this case is given by

   $$f = \frac{1}{4}(c_2^\dagger \lambda^\alpha c_1)(c_3^\dagger \lambda^\alpha c_4)\,. \tag{2}$$

   Evaluate f for the *singlet* configuration $(r\bar{r} + b\bar{b} + g\bar{g})/\sqrt{3}$. Can you explain the result?

   (c) [15 points] Calculate the qq color factor

   $$f = \frac{1}{4}(c_3^\dagger \lambda^\alpha c_1)(c_4^\dagger \lambda^\alpha c_2) \tag{3}$$

   for the *sextet* configuration using the state $(bg + gb)/\sqrt{2}$. Do the same for the *triplet* configuration using the state $(bg - gb)/\sqrt{2}$.

2. **Inverse Muon Decay:** [10 points] Complete the intermediate steps of the inverse muon decay calculation discussed in class and show that the total cross section for the process $\nu_\mu + e^- \to \mu^- + \nu_e$ is

   $$\sigma = \frac{1}{8\pi}\left[\left(\frac{g_w}{M_W c^2}\right)^2 \hbar c E \left\{1 - \left(\frac{m_\mu c^2}{2E}\right)^2\right\}\right]^2, \tag{4}$$

   where E is the electron energy in the CM frame. Make a plot of $\sigma(E)$.

3. **Bonus:** [10 points] Please complete the online course evaluation. You should have already received an email with a link. If not, please let me know soon.