

Physics 842
Particle Physics, Winter Term 2008
Midterm I

Thursday Feb 14th 2008, 9:30 am.

Professor Meadows

[To be handed in by 5 pm Tuesday Feb 19th, 2008]

Name

Question 1

In the "toy ABC" theory, all interactions are described by a single vertex at which three spin-less particles - A, B and C (one of each only) - can interact. The masses of these particles are such that:

$$m_A > m_B > m_C \ ; \ m_A > (m_B + m_C)$$

- a) Is the scattering $A + B \rightarrow A + C$ possible in lowest order?
[15 points]
- b) Draw the lowest order diagrams for the reaction $A + B \rightarrow A + B$.
[15 points]
- c) Write down the matrix element for the reaction $A + B \rightarrow A + B$ for lowest order processes.
[15 points]
- d) Compute $d\sigma/d\Omega$ for the reaction $A + B \rightarrow A + B$ in lowest order.
[15 points]

Question 2

- a) Write down the parity transformed Dirac spinor corresponding to

$$u(p) = \frac{Nc}{E + mc^2} \begin{pmatrix} E/c + mc \\ 0 \\ p_z \\ p_x + ip_y \end{pmatrix}$$

(Hint: What operator is used for P on Dirac spinors?)

- b) Show that the spinor for an electron at rest is an eigenstate of parity. [15 points]
- c) Show that the spinor for a positron at rest is also an eigenstate of parity. [15 points]
- d) How are the parity of the electron and positron related? [15 points]

Question 3

- a) Sketch the lowest order diagram (more than one if you think there are more) contributing to elastic, electromagnetic scattering of a muon and a quark $\mu^- q \rightarrow \mu^- q$.

Are there any other diagrams ??

- [15 points]
- b) Use the Feynman rules to write down the matrix element \mathcal{M}_1 for the first diagram you sketched. [15 points]
- c) Use “Casimir’s trick” to evaluate the matrix element $\langle |\mathcal{M}_1|^2 \rangle$ summed over spins in the final state and averaged over the initial spins. [15 points]
- d) Evaluate this as a function of the 4-momenta p_{1-4} of the ingoing and outgoing particles. [15 points]