Kern- und Teilchenphysik II
Spring Term 2016

Exercise Sheet 2

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1. Operations with gamma matrices

Verify the following equations:

a) $$\gamma^0 \gamma^\mu \dagger \gamma^0 = \gamma^\mu$$

b) $$\gamma^\mu \gamma^\nu \gamma_\mu = -2\gamma^\nu$$

c) $$\gamma_\mu \gamma^\nu \gamma^\lambda \gamma^\mu = 4g^{\nu\lambda}$$

d) $$\gamma_\mu \not{a} \gamma^\mu = -2\not{a}$$

e) $$\gamma_\mu \not{a} \not{b} \gamma^\mu = 4a \cdot b$$

f) $$\gamma_\mu \not{a} \not{b} \not{b} \gamma^\mu = 4a \cdot b$$

3 pt

Where the notation $\not{a} = \gamma_\mu a^\mu$ was used. [Hint: use the anti-commutation relation $\{\gamma^\mu, \gamma^\nu\} = 2g^{\mu\nu}$]

2. Charge conjugation

The charge conjugation operator C takes a Dirac spinor Ψ into its charge-conjugate spinor Ψ_C:

$$\Phi_C = i\gamma^2 \Psi^*$$

a) Find the charge-conjugates of Dirac equation solution: u_1 and u_2. Compare them to v_1 and v_2.

2 pt

3. Feynman rules

Consider the following processes. Draw the diagrams contributing to each of them and write down the total amplitude for the specific process:

a) $$e^+ + e^- \to \gamma + \gamma$$

b) $$e^+ + e^- \to \mu^+ + \mu^-$$

c) $$e^+ + \mu^+ \to e^+ + \mu^+$$

3 pt

4. Electron-positron scattering

Consider now the electron-positron scattering.

a) Which are the diagrams contributing to this process?

b) Use the the Feynman diagrams to write the amplitude for this process.

c) Assume that electron and muon approach one another along the z direction, and that are scattered back along the same axis.

3 pt