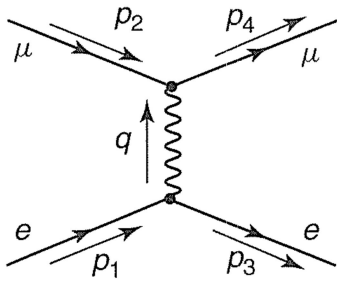


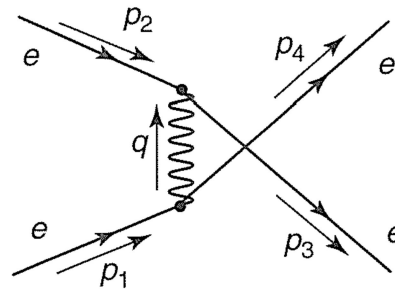
Lecture 14 : Dirac Equation -3

Examples for the scattering processes : See the D.Griffiths textbook “Int.Elementary Particles J.Wiley) for all the calculational details.

1. Electron-muon scattering $e^- + \mu^- \rightarrow e^- + \mu^-$



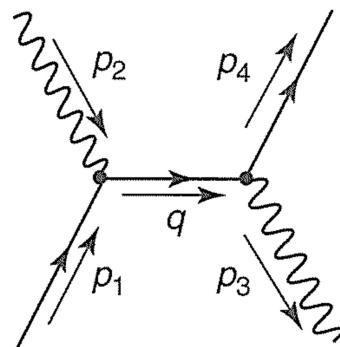
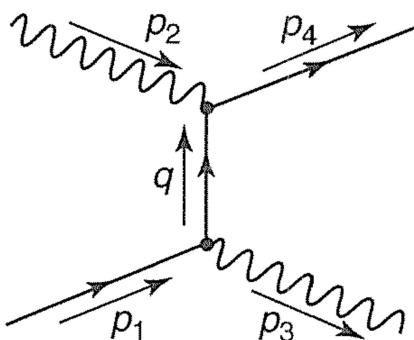
Feynman diagram for the process $e^- + \mu^- \rightarrow e^- + \mu^-$



Twisted Feynman diagram

2. Compton scattering $e^- + \gamma \rightarrow e^- + \gamma$

Tree level diagrams



3. Casimir trick : To do the sum over the spins using completeness relations and trace techniques.

4. Trace techniques :

$$\text{Tr}(A + B) = \text{Tr}(A) + \text{Tr}(B)$$

$$\text{Tr}(\alpha A) = \alpha \text{Tr}(A)$$

$$\text{Tr}(AB) = \text{Tr}(BA)$$

$$g_{\mu\nu}g^{\mu\nu} = 4$$

$$\gamma^\mu\gamma^\nu + \gamma^\nu\gamma^\mu = 2g^{\mu\nu}$$

$$\gamma^\mu\gamma^\nu + \gamma^\nu\gamma^\mu = 2g^{\mu\nu}$$

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

$$\gamma_\mu\gamma^\nu\gamma^\lambda\gamma^\sigma\gamma^\mu = -2\gamma^\sigma\gamma^\lambda\gamma^\nu$$

$$\text{Tr}(\gamma^\mu\gamma^\nu\gamma^\lambda\gamma^\sigma) = 4(g^{\mu\nu}g^{\lambda\sigma} - g^{\mu\lambda}g^{\nu\sigma} + g^{\mu\sigma}g^{\nu\lambda})$$

$$\text{Tr}(\gamma^5\gamma^\mu\gamma^\nu\gamma^\lambda\gamma^\sigma) = 4i\epsilon^{\mu\nu\lambda\sigma}$$

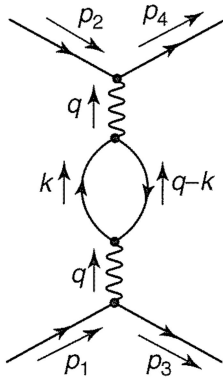
Trace of a product of odd number of the gamma matrices is zero.

5. Cross sections and lifetimes

- Rutherford scattering
- Pair annihilation

6. Renormalization concept

Example : Vacuum polarization diagram (a fourth order correction)



For all the details of the calculations and interpretation of the results see the textbook by D.Griffiths' "Intr. to Elementary Particles, J.Wiley"

Study Exercise 1 : Work out in detail the Examples 7.7 and 7.8 from the textbook "Introduction to Elementary Particles by D.Griffiths J.Wiley Pub."

Homework Problems : Solve the following problems from the textbook by D.Griffiths' "Intr. to Elementary Particles, J.Wiley"

- a) Problem 7.12
- b) Problem 7.13
- c) Problem 7.14
- d) Problem 7.15
- e) Problem 7.16
- f) Problem 7.16
- g) Problem 7.17