Lecture 5: Exercises

Exercises belonging to Lecture 5

Exercise – 17: Pion Decay

Griffiths exercise 6.6

Calculate the lifetime of the neutral pion π^0

The neutral pion decays mainly via: $\pi^0 \rightarrow \gamma\gamma$. Assume that the amplitude has dimensions $[\text{mass}] \times [\text{velocity}]$. Griffiths: $\pi^0 = \frac{1}{\sqrt{2}}\left(u\bar{u} - d\bar{d}\right)$

a) Motivate the reason that the amplitude should be proportional to the coupling constant: $\mathcal{M} \propto \alpha = e^2/4\pi$. Sketch a diagram of the decay.

For dimensional reasons $\mathcal{M}$ is of the form $\mathcal{M} = \alpha m_\pi$

b) Use Fermi's golden rule for two-body decays to estimate the decay width Γ of the pion. What are $S, m_A, |\vec{p}|$? Express Γ in GeV.

c) Use the conversion table to calculate the lifetime of the π^0 and compare it with the experimental value. What do you think?

Exercise – 18: Two-to-Two Scattering

Griffiths exercise 6.15

Consider the process: $A + B \rightarrow A + B$ in the ABC theory

a) Draw the (two) lowest-order Feynman diagrams, and calculate the amplitudes

b) Find the differential cross-section in the CM frame, assuming $m_A = m_B = m$, $m_C = 0$, in terms of the (incoming) energy E and the scattering angle θ.

c) Assuming next that B is much heavier than A, calculate the differential cross-section in the lab frame.

d) For case c), find the total cross-section.