Particle Physics 2 : Exercise 8

1) Feynman diagrams

Draw all possible lowest-order Feynman diagrams for the processes :

$$e^+e^- \to \mu^+\mu^-, \quad e^+e^- \to \nu_\mu\bar{\nu}_\mu, \quad \nu_\mu e^- \to \nu_\mu e^-, \quad \text{and,} \quad \bar{\nu}_e e^- \to \bar{\nu}_e e^-.$$

2) π^0 decays

Draw the lowest-order Feynman diagram for the decay $\pi^0 \to \nu_\mu\bar{\nu}_\mu$ and explain why this decay is effectively forbidden.

3) Partial decay rate

Starting from the matrix element, work through the calculation of the $Z \to \bar{f}f$ partial decay rate in the limit where the two fermions are ultrarelativistic. Express the answer in terms of the vector coupling c_V and the axial-vector coupling c_A of Z. Taking $\sin^2\theta_W = 0.2315$, show that

$$R_\mu = \frac{\Gamma(Z \to \mu^+\mu^-)}{\Gamma(Z \to \text{hadrons})} \approx \frac{1}{20}$$