[Tutorials on Thursdays: 8-10 in C01-148 and 16-18 in U2-135]

Exercise 7.1:
Consider a theory of three kinds of spin-0 particles, which are coupled via the Lagrange density $\widehat{\mathcal{L}}_{\rm int} = g\widehat{\phi}_A\widehat{\phi}_B\widehat{\phi}_C$. Suppose that we have $m_A > m_B + m_C$ with $m_B \neq m_C$ and $m_B, m_C > 0$, such that the decay $A \to B + C$ is kinematically allowed.

(a) Draw all possible connected Feynman diagrams with the interaction $\widehat{\mathcal{L}}_{\rm int}$ of order $\mathcal{O}(g)$, $\mathcal{O}(g^2)$ and $\mathcal{O}(g^3)$. Pay attention to which Feynman diagrams are kinematically allowed.

(b) What is the amplitude of the decay process $A \to B + C$ to order $\mathcal{O}(g^3)$?

Exercise 7.2:
Identify the channels in the scattering process $A + B \to 1 + 2$, which correspond to the particular Mandelstam variables $s = (Q_A + Q_B)^2$, $t = (Q_A - P_1)^2$ and $u = (Q_A - P_2)^2$. The interaction is governed by $\mathcal{L}_{\rm I} = g_{ijk}\Phi^i\Psi^j\Sigma^k$ of three arbitrary kinds of particles (in particular they can have different spin). *Hint:* The conservation of four-momentum $Q_A + Q_B - P_1 - P_2 = 0$ is helpful as well as the following interpretation of Feynman diagrams, where the main connections of external field lines can be associated with the Mandelstam variables.

Exercise 7.3:
Compute the amplitudes of the following processes from QED:

(a) Bhabha scattering: $e^-(\vec{q}_A, \vec{s}_A) + e^+(\vec{q}_B, \vec{s}_B) \to e^-(\vec{p}_1, \vec{s}_1) + e^+(\vec{p}_2, \vec{s}_2)$
Find an expression for the amplitude in terms of the spinors $\bar{u}(\vec{p}_1, \vec{s}_1)$, $v(\vec{p}_2, \vec{s}_2)$, $u(\vec{q}_A, \vec{s}_A)$ and $\bar{v}(\vec{q}_B, \vec{s}_B)$.

(b) Pair production: $\gamma(\vec{q}_A, \vec{\lambda}_A) + \gamma(\vec{q}_B, \vec{\lambda}_B) \to e^-(\vec{p}_1, \vec{s}_1) + e^+(\vec{p}_2, \vec{s}_2)$
Find an expression for the amplitude in terms of the spinors $\bar{u}(\vec{p}_1, \vec{s}_1)$, $v(\vec{p}_2, \vec{s}_2)$ and in terms of the electromagnetic potentials $A^\mu(\vec{q}_A, \vec{\lambda}_A)$, $A^\mu(\vec{q}_B, \vec{\lambda}_B)$.