Physikalisches Institut
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Theoretische Physik

Exercise 5
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Crash Course in Theoretical Particle Physics

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–Homework Exercises–

Practice, Practice, Practice!

The main goal of the crash course is that all students who want to participate in the "Theoretical Particle Physics" course should know the principles of calculating Feynman Diagrams. The involved techniques must usually be practiced several times before one really understands the underlying ideas. We therefore highly encourage everyone, as a first step, to do the in-class exercise again without any assistance, until all steps are fully understood and the result can be reproduced.

To get some more practice, we propose the following additional exercises:

- Calculate the differential cross section for the related process $\psi(p_1)\psi(p_2) \to \psi(k_1)\psi(k_2)$, that is the scattering of particles only. You can find solutions to this exercise in `http://www.itp.phys.ethz.ch/education/hs13/qft1/sheets/sheet12f`.
- The interaction of charged pions with leptons ℓ and neutrinos ν can be written with $\mathcal{L}_{\text{int}} = G\phi_\pi \bar{\psi}_\ell \not{p}_\pi (1-\gamma^5)\psi_\nu$. The overall structure of the calculation stays exactly the same, you'll just end up with more gamma matrices in your traces. Try to calculate the total decay width $\Gamma(\pi^+ \to \ell^+\nu)$. You should find the well-known property that pions predominantly decay into the heavier muon than the lighter electron. You can find intermediate steps of the calculation and the solution here `http://rjs.phys.uvic.ca/sites/rjs.phys.uvic.ca/files/lec15.pdf`.
- It is just a tiny step from Yukawa theory to Quantum Electrodynamics, which you will investigate further at the beginning of the actual lecture. If you feel confident in doing the above calculations, you can try doing QED calculations. A nice exercise with lots of intermediate results can be found in Ex 7.2 here `http://www.th.physik.uni-bonn.de/nilles/exercises/ws13/TPP/sheet07.pdf`.