



Kern- und Teilchenphysik II Exercise Sheet 1

HS 16
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<http://www.physik.uzh.ch/de/lehre/PHY213/FS2017.html>

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Exercise 1: Conservation laws (3.5 Pts.)

Under which interactions are the following interactions possible (please note that some of the processes) are not possible at all):

- $\pi^- p \rightarrow \pi^0 n$
- $\pi^0 \rightarrow \gamma\gamma\gamma$
- $\pi^0 \rightarrow \gamma\gamma$
- $\pi^+ \rightarrow \mu^+ \nu_\mu$
- $\pi^+ \rightarrow \mu^+ \bar{\nu}_\mu$
- $p\bar{p} \rightarrow \Lambda_0 \Lambda_0$
- $p\bar{p} \rightarrow \gamma$

Exercise 2: Forbidden decays (2.0 Pts.)

Which conservation laws forbade the following decays:

- $n \rightarrow pe^-$
- $n \rightarrow \pi^+ e^-$
- $n \rightarrow p\pi^-$
- $n \rightarrow p\gamma^-$

Exercise 3: Suppressed decays (2.0 Pts.)

Which conservation laws forbade or suppress the following processes:

- $pn \rightarrow p\Lambda^0$
- $K^+ \rightarrow \pi^- \pi^+ \pi^- \pi^+ \pi^+ \pi^0$
- $\Lambda_0 \rightarrow K^0 \pi^0$

- $K \rightarrow \pi\gamma$
- $K^- \rightarrow \pi^0 e^-$
- $K^+ \rightarrow \pi^+ \pi^- \pi^0$

Exercise 4: Pion decay (16 Pts.)

Please calculate the matrix element of the decay $\pi^- \rightarrow \mu\nu_\mu$. The form factor for the pion has the form of $F^\mu = p_\mu f_\pi$, where f_π is so called pion decay constant and is calculated on lattice to be $f_\pi = 130$ MeV. Using the matrix element calculate the Γ . Calculate also the Γ for the $\pi^- \rightarrow e\nu_e$. Why is the electron mode different then the muon one?

Please read about the "Casimir trick" in the D. Griffiths handbook (Sec. 7.7).

Exercise 5: Muon decay (16 Pts.)

Calculate the matrix element for the decay of the muon: $\mu^- \rightarrow e^- \nu_\mu \bar{\nu}_e$. Using "Golden Rule" calculate the Γ and the lifetime of the muon.

Exercise 6: Muon decay simulation (12 Pts.)

Please simulate the muon decay from exercise 5 using ROOT. Please assume for the moment flat phase space (aka matrix element =1). The example can be found:

<https://root.cern.ch/root/html/tutorials/physics/PhaseSpace.C.html>

having simulate this decay please calculate the electron energy in the muon central of mass and draw it for your simulated events. Simulate at least 100.000 events.