



Theoretical Physics

HOMWORK PROBLEMS #1
SI2400 THEORETICAL PARTICLE PHYSICS, 7.5 CREDITS
SPRING 2019

Deadline: April 11, 2019 @ 17:00
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1. Basics: Natural Units, Relativistic kinematics, and Conservation laws:

- (1 pt) The decay width of the Higgs boson in natural units is $\Gamma_H \approx 6$ MeV. What is the corresponding lifetime in S.I. units? Compare with the lifetime of the muon.
- (1 pt) Can a photon decay to two muons in vacuum? Explain your reasoning.
- (2 pts) Calculate the amplitude for the u-channel of the process $H_1, H_1 \rightarrow H_2, H_2$ (via S) in the scalar theory.
- (2 pts) Draw the lowest order Feynman diagrams involving τ in QED.
- (2 pts) Show that for the decay $a \rightarrow 1, 2$ the momenta of either 1 and 2 in the centre-of-mass frame are

$$p_{1,2} = \frac{1}{2m_a} \sqrt{(m_a^2 - (m_1 + m_2)^2)(m_a^2 - (m_1 - m_2)^2)} \quad (1)$$

2. QED:

- (2 pts) Show that the photon propagator is the origin of the $1/\sin^4(\frac{\theta}{2})$ dependence of the Rutherford cross section for $ep \rightarrow ep$ scattering (consider QED with the additional vertex: $p\bar{p}\gamma$, where \bar{p} is the anti-proton. Assume that the proton is elementary.)
- (2 pts) Can you easily obtain the cross-section of the process $e^+e^- \rightarrow e^+e^-$ from the result of $e^+e^- \rightarrow \mu^+\mu^-$? If yes: give the result, if no: why not?
- Consider scattering of electrons with π^\pm pions (note that pions are spin-0 particles, and ignore their substructure.)
 - (2 pts) Consider the process of electron-pion scattering: $e^+\pi^- \rightarrow e^+\pi^-$. Draw its leading order Feynman diagram(s) and write down the expression for the amplitude \mathcal{M} using the Feynman rules.
 - (2 pts) Perform the "averaging over initial spins and sum over final spins" to compute $\langle |\mathcal{M}|^2 \rangle$.
 - (2 pts) Determine the differential cross-section $\frac{d\sigma}{d\Omega}$ for this process in the pion rest-frame.