Master's thesis – track Theoretical Physics

'CP Violation in D0 Decays - A Signal of New Physics?'

Abstract:
The recent discovery of the Higgs boson represents the last success of a series of successes of the Standard Model (SM). However, there are observations that suggest that the SM is incomplete, this motivates many physicists to search for new physics (NP). A recent LHCb measurement deviates significantly from the naive Standard Model expectation and might represent a sign of NP. The LHCb collaboration measured ¢ACP ≡ ACP (D0 → K+K−) − ACP (D0 → π+π−) = [−0.82 ± 0.21 ± 0.11]%, where ACP (D0 → h+h−) with h ∈ {π,K} is a CP asymmetry that quantifies the rate difference of the decays D0 → h+h− and ¯D0 → h+h−. It is necessary to evaluate whether this deviation is actually due to new physics or whether it can be accommodated in the SM. In this Master thesis, we discuss a possible theoretical explanation of ¢ACP within the SM. First, we derive the SM expression of ¢ACP and argue that it naively has a value at the 10−4 level. The main uncertainty of this expectation for ¢ACP is due to unknown (hadronic) matrix elements which are a consequence of the non-calculable long-distance contributions of the strong interactions. However, different matrix elements of D decays can be related by the SU(3) flavor symmetry so that this symmetry can be used to express all charm decay amplitudes by a small number of parameters (topologies). The SU(3) symmetry holds only approximately and we find that especially for the decays D0 → π+π− and D0 → K+K− we have to include SU(3)-breaking effects. We investigate three different kinds of SU(3) breaking. This leads us to a framework in which a large value for ¢ACP is possible, so that we find that ¢ACP could be accommodated in the SM. However, we cannot exclude that ¢ACP is generated by NP.