



Physics Beyond The Standard Model and Aspects of Decaying Implications

Thesis Submitted to The Physics Department, Faculty of Science, Ain
Shams University, In Partial Fulfillment of The Requirement for The
Degree of Master of Science of Theoretical Physics

by

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Dedicated to

My Father

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Summary

The aim of this thesis is to analyze the CP asymmetry of the $B^- \rightarrow D^0 K^-$ decay within the standard model SM and the minimal supersymmetric standard model MSSM, and to compare our results with the experimental values of babar collaborations.

This thesis consists of four chapters:

Chapter 1 gives a review on the gauge principle for gauge theories which are $U(1)$ gauge theory as an example for abelian-gauge theory (QED), as well as $SU(2)$ and $SU(3)$ as examples of non-abelian gauge theories, it also spots light on the phenomenology of the weak interaction that studied through some theories such as : Fermi-theory, V-A theory of Feynman and Gell-man and IVB theory of Lee, Yang and Glashow.

Chapter 2 we present an introduction of the construction of the electroweak interaction theory, and we give a review on symmetry modes and symmetry breaking mechanism that includes that Goldstone and Higgs mechanism, we discuss the symmetry breaking sector of the

electroweak theory, this chapter shows the role of the Higgs Mechanism in generating masses for gauge bosons and fermions, the Lagrangian formalism of the standard model is also discussed in this chapter.

Chapter 3 introduces the supersymmetric theory which involves: susy algebra, superspace and superfield as well as vector and chiral superfields. It also gives an introduction to the minimal supersymmetric standard model MSSM and SUSY breaking terms that includes breaking SUSY spontaneously and soft SUSY-breaking terms, also this chapter represents the superpotential and electroweak symmetry breaking in MSSM, the supersymmetric particles of the MSSM and their spectrum.

Chapter 4 is devoted to study the asymmetry of $B^- \rightarrow D^0 K^-$ decay within the SM and the MSSM models through the following stages:

- In the standard model SM, we compute SM contributions to the $b \rightarrow u(\bar{c}s)$ and $b \rightarrow c(\bar{u}s)$ transitions at the tree level since all other loop contributions in this model are suppressed by the CKM factors $V_{cs}V_{ub}^*$ and $V_{us}V_{cb}^*$ which are of the order 10^{-3} . This gives the hope that it may be possible for a new physics beyond the SM.
- In the MSSM, we derived the effective Hamiltonian to compute SUSY contributions to the $b \rightarrow u(\bar{c}s)$ and $b \rightarrow c(\bar{u}s)$ through gluino and chargino exchange. We showed that the gluino box diagrams give the dominant SUSY contributions while the chargino lead to the subdominant contributions.

- We analyze the charged asymmetries $A_{CP\pm}$ of the $B^- \rightarrow D^0 K^-$ decay in two scenarios for supersymmetry, namely:
 - Minimal Super Gravity (mSUGRA) where the only source of the weak phase is the standard model CKM source phase.
 - Non-minimal flavor violation where there are possible weak phases that can originate from the soft breaking terms.

We compare our results with experimental values of Babar collaborations that have measured the charged CP asymmetries $A_{CP\pm}$ of the $B^- \rightarrow D^0 K^-$ decay. We found that

- In mSUGRA, the gluino and chargino contributions to the Wilson coefficients vanish since in mSUGRA the mixing between the first two generations of squarks mass matrices is negligible and thus the charged asymmetries will not be affected by considering supersymmetry.
- In the non-minimal flavor violation scenario, where the mixing between the first two generations of the squark is not neglected and there are new source of the weak phases that can enhance the asymmetries, we found that the charged asymmetry A_{CP+} is enhanced and became consistent with experimental results. This shows that supersymmetry can solve some of the problems that can not be solved in the standard model .

Introduction

The standard model (SM) is a consistent, finite and computable theory of fundamental microscopic interactions within the limitation of our present technical abilities. It provides an accurate description of most of the known phenomena in elementary particle physics. Its structure is a generalization of quantum electrodynamics (QED) in the sense that it is a renormalizable field theory based on a local symmetry (i.e. the continuous parameter depends on space-time point x) that extends the gauge invariance of electromagnetic to a large set of conserved current and charges. The standard model describes strong, weak and electromagnetic interactions specified by the $SU(3)_C \times SU(2)_L \times U(1)_Y$ gauge symmetries. For each of those symmetries one may associate a dynamical gauge fields, i.e.

- A gluon fields G_μ^a , ($a = 1, \dots, 8$) that interacts with the $SU(3)_C$, where C stands for the color quantum number .
- A weak boson fields W_μ^i , ($i = 1, \dots, 3$) that interacts with the isospin quantum number (I).
- An abelian field B that interacts with the hypercharge (Y).

These are two types of the basic building blocks of the SM:

- The first one is fermions of spin $s = \frac{1}{2}$ and are classified into leptons and quarks. The known leptons are: the electron, e^- , the muon, μ^- and the tau, τ^- with electric charge $Q = -1$ and the corresponding neutrinos ν_e , ν_μ and ν_τ with electric charge $Q = 0$. The known quarks are of six different flavours: u, d, s, c, b and t and have fractional charge, $Q = \frac{2}{3}, -\frac{1}{3}, -\frac{1}{3}, \frac{2}{3}, -\frac{1}{3}$ and $\frac{2}{3}$.
- The second type of elementary particles is the intermediate interaction particles. By leaving apart the gravitational interaction, all the relevant interactions in the particle physics are mediated by the exchange of an elementary particle that is a boson with spin $s = 0$. The fact that the weak gauge bosons are massive particles, $M_W^\pm, M_Z \neq 0$ indicates that $SU(2)_L \times U(1)_Y$ is NOT a symmetry of the vacuum. In contrast, the photon being massless reflects that $U(1)_{em}$ is a good symmetry of the vacuum. Therefore, the Spontaneous Symmetry Breaking pattern in the SM must

$$SU(3)_C \times SU(2)_L \times U(1)_Y \rightarrow SU(3)_C \times U(1)_{em}$$

The above pattern is implemented in the SM by means of the so-called Higgs Mechanism which provides the proper masses to the $M_W^\pm$ and M_Z gauge bosons and to the fermions and leaves as a consequences the prediction of a new particle, The Higgs boson particle.

One of the most subject in physics is the symmetry or invariance, its important arises from that it gives a simple and consistent way to construct lagrangian from which the equation of motion can be found for

the fields or particles of interest. Supersymmetry (SUSY) is different from all earlier in that it is an invariant under transformations of bosons into fermions and vice versa, i.e. it does not conserve statistics.

Supersymmetry combines bosons and fermions in a single representation called a superfield. This means that if Supersymmetry were present in nature, each fermion and each boson have a supersymmetric partner with the same mass and the same quantum numbers, only different spins and obeying different statistics. This is apparently not the case, since the observed particle spectrum gives no indications of such partner for any of the observed particles. Therefore, Supersymmetry, if inherent in nature, must be broken, thus differentiating the masses of the supersymmetric partners from those of particles.

In this thesis we provide a review on the SM and the minimal supersymmetric standard model (MSSM) and focus on the charge CP asymmetry $A_{CP_{\pm}}$ of the decay $B^- \rightarrow D^0 K^-$ in two models

- In the standard model SM, we compute the charge CP asymmetry $A_{CP_{\pm}}$ of the $b \rightarrow u(\bar{c}s)$ and $b \rightarrow c(\bar{u}s)$ transitions at the tree level since all other loops are suppressed by the V_{CKM} factors $V_{cs}V_{ub}^*$ and $V_{us}V_{cb}^*$ which are of the order 10^{-3} .
- In the MSSM we compute the charge CP asymmetry ($A_{CP_{\pm}}$) of the $b \rightarrow u(\bar{c}s)$ and $b \rightarrow c(\bar{u}s)$ transition through gluino and chargino exchange, we found that the gluino box diagrams give the dominant SUSY contributions while the chargino exchange leads to the subdominant contributions.