CHAPTER 5

SUMMARY

5.1Conclusion

This thesis is based on some phenomenological aspects of B-physics. In this chapter we summarize the thesis and point out the main results of our work. In Chapter 1, we discuss how CP violation in the quark sector is introduced in the SM through the CKM mechanism; which processes should be examined to acquire information about the CKM matrix elements; how CKM matrix can be parametrized. We discuss two popular parametrizations of CKM matrix: (i) Standard parametrization and (ii) Wolfenstein Parametrization. This is followed by a detailed discussion of the unitarity triangle and its parameters. We discuss how experiments and global fits are indicating that the CKM matrix is the dominant source of CP violation in the SM. We conclude this chapter indicating some of the reasons to suspect that SM is insufficient to explain nature completely and we probably need some new physics to understand it better.

In Chapter 2, we present one of the most exciting puzzles of B physics in a model independent way: The variation of the measured $B^0_d - \bar{B}^0_d$ mixing phase $\beta/\phi_1$ in $b \rightarrow c\bar{c}s$ and $b \rightarrow s\bar{q}q$ (where $q = u, d, s$) modes is regarded as a possible probe of New Physics. Within the Standard Model, the amplitude for modes involving $\bar{b} \rightarrow \bar{s}$ transitions receive contributions from two amplitudes with different weak phases. Unless one of the amplitudes is negligible, some deviation is in fact expected. Estimates of this discrepancy using hadronic assumptions, however, are unable to produce the observed effect; indeed, the sign of the discrepancy within SM is opposite to the observed
value. Convincing arguments regarding the true nature of this discrepancy are lacking. In light of this, the relevant question is “Under what conditions can this discrepancy be regarded as an unambiguous signal of NP?” In this thesis we address this question using a model independent approach.

We demonstrate that the deviation in the measured $\beta/\phi_1$, within the SM, due to pollution from another amplitude, is not only always less than the weak phase of the polluting amplitude, but also has always the same sign as the weak phase of the polluting amplitude. The only exception is to have large destructive interference between the two amplitudes. Without making any hadronic model-based assumptions, we examine the conditions under which such a destructive interference is possible within the SM. We find that a deviation larger than a few degrees is possible only if the observed decay rates result from fine-tuned cancellations between amplitudes whose squares are at least an order of magnitude larger than the decay rates themselves. This can be tested at near-future Super-B factories.

In Chapter 3, we discuss various phenomenological aspects of K and B mesons within SM. This forms the basis for the calculation in Chapter 4. We address the neutral $K^0 - \bar{K}^0$, $B^0_d - \bar{B}^0_d$ and $B^0_s - \bar{B}^0_s$ mixing in this chapter. The SM scenario of neutral K and B mesons mixing correlated leptonic and semileptonic decays are presented after that.

In Chapter 4, we discuss the Lepto-Quark Model which is one of the promising candidates for a NP model. Our model is based on the scalar type of leptoquarks with baryon and lepton number conserving renormalizable couplings, consistent with the symmetries of the SM. At low energies, leptoquarks could induce two-lepton two-quark interactions, like those mediated by the electroweak four-fermion vertices. This suggests that the leptoquark Yukawa coupling-squared ($\equiv \lambda^2$), divided by the mass-squared ($\equiv m_{lq}^2$) is at least as small as the weak coupling $G_F$.

In this work we compute the bounds on the product couplings of the type $\lambda \lambda$ coming from $K^0 - \bar{K}^0$, $B^0_d - \bar{B}^0_d$ and $B^0_s - \bar{B}^0_s$ mixing. Though such an analysis is not new, we implement several features in this analysis which were not taken care in earlier studies. Previously there was a lower limit only on $\Delta m_{B_s}$. Here we use the current bound on it and $\sin 2\beta_s$ limit also. We consider the
exact expression for the box amplitude taking all possible processes, including
the one from the SM. The possibility that the LQ product couplings may be
complex is also considered. The analysis is done assuming all leptoquarks
are degenerate at 300 GeV. The interference between charge (-1/3) LQ and
charge (-4/3) LQ for $S_1$ and charge (1/3) LQ and charge (-2/3) LQ for $\tilde{S}_{1/2}$ are
considered here. Similar assumption is taken for the same type of couplings.
We consider that only one LQ is present at a time. The constraints obtained
for the leptonic and semi leptonic decay modes are much tighter than the
bounds obtained from mixing. We find that a number of them have better
bounds from their previous bounds. We present the bounds on the real
and imaginary parts of $\lambda\lambda$ which carry the information of the phase of new
physics. This is a new observation which was not taken into account earlier.