Exclusive $B \to \rho l^+ l^-$ decay in the standard model with fourth-generation quarks

K. Zeynali[1,*] and V. Bashiry[2,+]

[1]*Faculty of Medicine, Ardabil University of Medical Sciences (ArUMS), Daneshgah Street, Ardabil, Iran*
[2]*Engineering Faculty, Cyprus International University, Haspolat-Lefkosa, North Cyprus, via Mersin 10, Turkey*
(Received 16 April 2008; published 5 August 2008)

We investigate the influence of the fourth generation of quarks on the branching ratio, the CP asymmetry, and the polarization asymmetries in $B \to \rho \ell^+ \ell^-$ decay. Taking $|V_{t'd}V_{t'b}| \sim 0.001$ with phase about 10°, which is consistent with the $\sin 2\phi_1$ of the Cabibbo-Kobayashi-Maskawa matrix and the B_d mixing parameter Δm_{B_d}, we obtain that for both (μ, τ) channels the branching ratio is increased and the magnitude of CP asymmetry and polarization asymmetries decreased by the mass and mixing parameters of the 4th generation of quarks. These results can serve as a good tool to search for new physics effects, precisely, to search for the fourth generation of quarks (t', b') via its indirect manifestations in loop diagrams.

DOI: 10.1103/PhysRevD.78.033001 PACS numbers: 12.15.Ji, 13.25.Hw

I. INTRODUCTION

Flavor changing natural current (FCNC) and lepton flavor violation (LFV) are at the forefront of our study both for precision test of the standard model (SM) and for new physics effects. FCNC, forbidden in the tree level, is induced by the quantum loop level. The new physics (NP) can either contribute to the effective Hamiltonian by the new operators which are absent in the SM or alter the Wilson coefficients of the Hamiltonian. A consequential extension of the SM with a new generation of fermions belongs to the classes of the new physics where the Wilson coefficients change comparing to the corresponding three-generation standard model (SM3).

The existence of the 4th generation of fermions, if their mass is less than the half of the mass of the Z boson, is excluded by the CERN LEP II experiment [1]. In this sense, the status of the fourth generation is more subtle [2] from the experimental point of view. However, a consequential extension of the SM3 can address some of the puzzles and fundamental questions from the theoretical point of view. In this respect, the consequential 4th generation of quarks and leptons are interesting in different ways, i.e., [3–9]. The 4th generation of quarks can include new weak phases and mixings in the Cabibbo-Kobayashi-Maskawa matrix (CKM). Thus, the four-generation standard model (SM4) can demonstrate a better solution to the baryogenesis than the SM3.

Two type of studies can be conducted to discover the 4th generation of fermions. The first type is the direct search of the 4th generation of quarks and leptons which can be accessed by increasing the center of mass energy of colliders with high luminosity. Here the cross section of production will increase and such fermions can be created as real states; i.e., the 4th generation of quarks can be created by gluon-gluon fusion at CERN LHC [10]. The second type is the indirect search dealing with the effects of the 4th generation of fermions in the FCNC decays [3–9] and LFV [11]. In these classes of studies, one studies the contribution of the 4th generation of fermions at the quantum loop level; Ref. [11] studied the effects of the 4th generation of heavy neutrinos (heavier than the half of the Z boson mass) in the $\mu \to e\gamma$ decay and anomalous magnetic moment of the μ. The result was an upper limit for the mass of ν_4 which is up to ~100 GeV. Considering these constraints, one can study the branching ratio of the $\mu^- \to 2e^- e^+$ decay.

The $b \to s(d)$ transition is at the forefront for searching for the 4th generation of quarks. This transition is forbidden at tree level in the standard model. A consequential extension of the three-generation standard model to the four-generation standard model (SM4) maintains the same property at tree level, but at the quantum loop level the 4th generation of heavy quark (t') can contribute to the quantum loop. This contribution can affect physical observables, i.e. branching ratio, CP asymmetry, polarization asymmetries, and forward-backward (FB) asymmetries. The study of these physical observables is a good tool to look for the 4th generation of up-type quarks [3–9].

There are some constraints on a fourth family [12]. From the strong constraint on the number of light neutrinos, we know that the fourth family of neutrinos is heavy. The S and ρ parameter are sensitive to a fourth family, but the experimental limits on these parameters have been evolved through the years in such a way that the constraint on a fourth family has lessened. In addition, the masses of the fourth family of leptons may produce negative S and T. As discussed in [13] and the reference therein, the constraints from S and T do not prohibit the fourth family, but instead serve only to constrain the mass spectrum of the fourth family of quarks and leptons.

FCNC and CP violation (CPV) are indeed the most sensitive probes of NP contributions to penguin operators.

*k.zeinali@arums.ac.ir
+bashiry@ipm.ir

