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Penguin Effects on $K\pi$ and $\pi\pi$ Decays of the B Meson

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ABSTRACT

We give the detailed analyses for the gluonic-penguin effect on the $K\pi$ and $\pi\pi$ decays of the B meson. In the standard model, it is shown that the ratio $BR(B \to K\pi)/BR(B \to \pi\pi)$ takes the value $0.5 \sim 3.0$ with the strongly depending on the CP violating phase ϕ and the KM matrix element $|V_{ub}|$. We obtain the constraint on the form factor by using the experimental branching ratio. It is also found that, in the two-Higgs-doublet model, the charged Higgs contribution which could enhance the $B \to X_s\gamma$ decay does not a sizable effect on our processes. The effect of the final state interaction on these processes is also discussed.

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Until now, the rare B decays have been intensively studied in the standpoint of the standard model(SM) and also beyond the standard model. Especially, $b \to s\gamma$ and $b \to sg$ sub-processes have attracted one's attention in the circumstance that the experimental evidence has been found in CLEO [1]. These decays, induced by the flavour changing neutral current, are controlled by the one-loop penguin operators which involve the important SM parameters such as the top-quark mass and the Kobayashi-Maskawa matrix elements V_{ts} and V_{tb}[2]. In our previous papers [3], we analyzed the inclusive decay $B \to X_s\gamma$ and the exclusive decays $B \to K_X\gamma$, where K_X denotes the meson states in the $s\overline{q}(\overline{q} = \overline{u}$ or $\overline{d})$ system, as well as the exclusive decays $B \to K_X\phi$ by including the nonstandard physical effects due to the charged Higgs contributions in the two-Higgs-doublet model(THDM) [4][5].

In this paper, we study the $B \to K\pi$ and $B \to \pi\pi$ decays, which are induced by both tree processes and gluonic penguin ones, in the SM model. Now we take into account QCD corrections, which were not included in the previous calculations[6], since the QCD corrections have been found to give the important contributions to the rare decays of the B meson. Recently, CLEO Collaboration reported the following experimental result [7]:

$$BR(B_d^0 \to \pi^+\pi^- + K^+\pi^-) = (2.4^{+0.8}_{-0.7} \pm 0.2) \times 10^{-5} \ , \tag{1}$$

where the discrimination between the K^+ meson and the π^+ meson has not been suceeded. We will predict the ratio of the $B \to K\pi$ decay width to the $B \to \pi\pi$ one, the ratio being almost independent of the form factor. The magnitude of the relevant form factor can be restricted by the experimental branching ratio of eq.(1) as shown later. Furtheremore, we will examine the nonstandard effects due to the charged Higgs contribution in the THDM. Finally, the effect of the phase shifts due to the final state interactions will be discussed as to our numerical results.

In the previous paper[5], we give the formulation including the QCD corrections for the rare decays of the B meson. The four-quark operators and the magnetic-transition-type ones are given for the processes under consideration in the the Hamiltonian [8][9],

$$H_{eff} = \frac{4G_F}{\sqrt{2}} \left[v_u \sum_{i=1}^{2} C_i(\mu) O_i(\mu) + v_t \sum_{i=3}^{8} C_i(\mu) O_i(\mu) \right] \ , \tag{2}$$

where the factor v_q(q=u,t) is defined by

$$v_q = \begin{cases} V_{qb} V_{qs}^* & \text{for } b \to s \\ V_{qb} V_{qd}^* & \text{for } b \to d \end{cases} \ . \tag{3}$$

For the $b \to s$ transition, each operator O_i is defined as follows:

$$\begin{aligned}
O_1 &= (\overline{q}_{L\alpha} \gamma^\mu b_{L\beta})(\overline{s}_{L\beta} \gamma_\mu q_{L\alpha}) \ , \\
O_2 &= (\overline{q}_{L\alpha} \gamma^\mu b_{L\alpha})(\overline{s}_{L\beta} \gamma_\mu q_{L\beta}) \ , \\
O_3 &= (\overline{s}_{L\alpha} \gamma^\mu b_{L\alpha})(\sum_{\text{5 quarks}} \overline{q}'_{L\beta} \gamma_\mu q'_{L\beta}) \ , \\
O_4 &= (\overline{s}_{L\alpha} \gamma^\mu b_{L\beta})(\sum_{\text{5 quarks}} \overline{q}'_{L\beta} \gamma_\mu q'_{L\alpha}) \ , \\
O_5 &= (\overline{s}_{L\alpha} \gamma^\mu b_{L\alpha})(\sum_{\text{5 quarks}} \overline{q}'_{R\beta} \gamma_\mu q'_{R\beta}) \ , \\
O_6 &= (\overline{s}_{L\alpha} \gamma^\mu b_{L\beta})(\sum_{\text{5 quarks}} \overline{q}'_{R\beta} \gamma_\mu q'_{R\alpha}) \ , \\
O_7 &= -i \frac{e}{8\pi^2} m_b \overline{s}_{L\alpha} \sigma^{\mu\nu} b_{R\alpha} q_\mu \epsilon_\nu \ , \\
O_8 &= -i \frac{g_c}{8\pi^2} m_b \overline{s}_{L\alpha} \sigma^{\mu\nu} T^a_{\alpha\beta} b_{R\beta} q_\mu \epsilon^a_\nu \ .
\end{aligned} \tag{4}$$

For the $b \to d$ transition, the s-quark is replaced by the d-quark in each of eq.(4). In addition to these operators, we need a new operator O_8', which is derived from O_8 through the coupling of the virtual gluon to $\overline{q'}q'$:

$$O_8' = i m_b \frac{\alpha_s}{2\pi} \frac{1}{q^2} \overline{q}_{L\alpha} \sigma^{\mu\nu} T^a_{\alpha\beta} b_{R\beta} q_\mu \overline{q}'_\beta \gamma_\nu T^a_{\beta\alpha} q'_\alpha \qquad (q = s \text{ or } d) \ , \tag{5}$$

where q_μ denotes the four-momentum of the virtual gluons. The coefficients relevant to the processes $B \to K\pi$ and $\pi\pi$ are defined at the energy scale of m_W as[8][9]

$$C_1(m_W) = 0 \ , \qquad C_2(m_W) = 1 \ ,$$

$$
\begin{aligned}
C_3(m_W) &= C_5(m_W) + \frac{\alpha}{6\pi \sin\theta_W^2} \times \\
&\quad [\frac{1}{2}(\frac{x_t}{1-x_t} + \frac{x_t \ln x_t}{(1-x_t)^2}) + \frac{x_t}{8}(\frac{x_t - 6}{x_t - 1} + \frac{3x_t + 2}{(1-x_t)^2}\ln x_t)] \ , \\
C_5(m_W) &= -\frac{\alpha_s(m_W)}{288\pi} G_1(x_t) \ , \\
C_4(m_W) &= C_6(m_W) = \frac{\alpha_s(m_W)}{96\pi} G_1(x_t) \ , \\
C_7(m_W) &= F(x_t) \ , \qquad\qquad C_8(m_W) = -\frac{1}{8} G_2(x_t) \ .
\end{aligned} \tag{6}
$$

The functions $G_i(x_t)$ and $F(x_t)$ are given by

$$
\begin{aligned}
G_1(x_t) &= \frac{x_t(1-x_t)(18 - 11x_t - x_t^2) - 2(4 - 16x_t + 9x_t^2)\ln x_t}{(1-x_t)^4} \ , \\
G_2(x_t) &= x_t \frac{(1-x_t)(2 + 5x_t - x_t^2) + 6x_t \ln x_t}{(1-x_t)^4} \ , \\
F(x_t) &= \frac{x_t}{24(1-x_t)^3}[8x_t^2 + 5x_t - 7 + \frac{6x_t(3x_t - 2)}{(1-x_t)}\ln x_t] \ ,
\end{aligned} \tag{7}
$$

with $x_t = m_t^2/m_W^2$.

In the following analysis, we take the value of the coefficient $C_8'(\mu)$ being equal to $C_8(\mu)$. Although $C_8(\mu)$ does not include the full QCD correction of $C_8'(\mu)$ in the leading *log* approximation, this replacement does not seriously affect the results numerically since the O_8' term is the next leading one compared to the operators O_3, O_4, O_5 and O_6. The similar operator O_7', which is induced from O_7 by the coupling of the virtual photon with $\overline{q}'q'$, is negligible due to $\alpha \ll \alpha_s$. We evolve the coefficients $C_i(\mu)$, by starting from the scale m_W as given in eq.(6) to the scale $\mu = m_b = 4.58$GeV, according to the renormalization group equation [10]. Then, we obtain

$$
\begin{aligned}
C_1(m_b) &= -0.240 \ , \qquad\qquad C_2(m_b) = 1.103 \ , \\
C_3(m_b) &= 0.011 + 1.125 C_3(m_W) - 0.121 C_4(m_W) \ , \\
C_4(m_b) &= -0.025 - 0.291 C_3(m_W) + 0.824 C_4(m_W) \ , \\
C_5(m_b) &= 0.007 + 0.944 C_3(m_W) + 0.083 C_4(m_W) \ ,
\end{aligned} \tag{8}
$$

$$
\begin{aligned}
C_6(m_b) &= -0.030 + 0.229C_3(m_W) + 1.465C_4(m_W) \ , \\
C_7(m_b) &= -0.199 + 0.629C_3(m_W) + 0.931C_4(m_W) + 0.675C_7(m_W) \\
&+ \ 0.091C_8(m_W) \ , \\
C_8(m_b) &= -0.096 - 0.598C_3(m_W) + 1.029C_4(m_W) + 0.709C_8(m_W) \ .
\end{aligned}
$$

However, the coefficients $C_3(m_b)$, $C_4(m_b)$, $C_5(m_b)$ and $C_6(m_b)$ do not completely involve the charm-quark loop effect. The charm-quark loop contributions are included by replacing these coefficients as follows[11]:

$$
\begin{aligned}
C_3(\mu) &\rightarrow C_3(\mu) + \frac{\alpha_s(\mu)}{24\pi} G(m_c, q, \mu) C_2(\mu) \ , \\
C_4(\mu) &\rightarrow C_4(\mu) - \frac{\alpha_s(\mu)}{8\pi} G(m_c, q, \mu) C_2(\mu) \ , \\
C_5(\mu) &\rightarrow C_5(\mu) + \frac{\alpha_s(\mu)}{24\pi} G(m_c, q, \mu) C_2(\mu) \ , \\
C_6(\mu) &\rightarrow C_6(\mu) - \frac{\alpha_s(\mu)}{8\pi} G(m_c, q, \mu) C_2(\mu) \ , \\
G(m_c, q, \mu) &= -4 \int_0^1 x(1-x) \ln \left[\frac{m_c^2 - q^2 x(1-x)}{\mu^2} \right] dx \ ,
\end{aligned} \tag{9}
$$

where the parameter q^2 denotes the square of the four-momentum of the virtual gluons. These values of the coefficients are numerically given as follows:

$$
\begin{aligned}
C_1(m_b) &= -0.240 \ , & C_2(m_b) &= 1.103 \ , \\
C_3(m_b) &= 0.0152 - 0.0058i \ , & C_4(m_b) &= -0.0380 + 0.0174i \ , \\
C_5(m_b) &= 0.0118 - 0.0058i \ , & C_6(m_b) &= -0.0427 + 0.0174i \ , \\
C_7(m_b) &= -0.320 \ , & C_8(m_b) &= -0.157 \ ,
\end{aligned} \tag{10}
$$

where q^2 is taken as $m_b^2/2$ [5][11]. The imaginary part of these coefficients follows from the loop integral $G(m_c, q, \mu)$. These values are in agreement with the ones given by Fleischer[11].

Let us begin with showing the decay amplitude of the $B \rightarrow K\pi$ process. By the use of the above operators, the decay amplitude is written as

$$
\begin{aligned}
\langle K\pi \mid H_{eff} \mid B\rangle &= \frac{4G_F}{\sqrt{2}} V_{ub}V_{us}^{*} \sum_{1,2} C_i(\mu)\langle K\pi \mid O_i(\mu) \mid B\rangle \\
&+ \frac{4G_F}{\sqrt{2}} V_{tb}V_{ts}^{*} \sum_{3,4,5,6,8'} C_i(\mu)\langle K\pi \mid O_i(\mu) \mid B\rangle \ . \qquad (11)
\end{aligned}
$$

We use the factorization approximation in order to estimate the hadronic matrix element. This factorization assumption successfully works in the D meson and B meson decays [12] within the factor two as to the branching ratios. Under this assumption, the hadronic matrix elements of the above operators are given as

$$
\begin{aligned}
\langle K^+\pi^- \mid O_1 \mid B_d^0\rangle &= -\frac{1}{12}\langle K^+ \mid \overline{s}\gamma_\mu\gamma_5 u \mid 0\rangle\langle \pi^- \mid \overline{u}\gamma^\mu b \mid B_d^0\rangle \ , \\
\langle K^+\pi^- \mid O_2 \mid B_d^0\rangle &= -\frac{1}{4}\langle K^+ \mid \overline{s}\gamma_\mu\gamma_5 u \mid 0\rangle\langle \pi^- \mid \overline{u}\gamma^\mu b \mid B_d^0\rangle \ , \\
\langle K^+\pi^- \mid O_3 \mid B_d^0\rangle &= -\frac{1}{12}\langle K^+ \mid \overline{s}\gamma_\mu\gamma_5 u \mid 0\rangle\langle \pi^- \mid \overline{u}\gamma^\mu b \mid B_d^0\rangle \ , \\
\langle K^+\pi^- \mid O_4 \mid B_d^0\rangle &= -\frac{1}{4}\langle K^+ \mid \overline{s}\gamma_\mu\gamma_5 u \mid 0\rangle\langle \pi^- \mid \overline{u}\gamma^\mu b \mid B_d^0\rangle \ , \\
\langle K^+\pi^- \mid O_5 \mid B_d^0\rangle &= -\frac{2}{3}\langle K^+ \mid \overline{s}_L u_R \mid 0\rangle\langle \pi^- \mid \overline{u}_R b_L \mid B_d^0\rangle \ , \\
\langle K^+\pi^- \mid O_6 \mid B_d^0\rangle &= -2\langle K^+ \mid \overline{s}_L u_R \mid 0\rangle\langle \pi^- \mid \overline{u}_R b_L \mid B_d^0\rangle \ , \\
\langle K^+\pi^- \mid O_8' \mid B_d^0\rangle &= -\frac{\alpha_s}{12\pi} m_b \frac{1}{q^2} q^\mu \Big(\langle K^+ \mid \overline{s}\gamma_\mu\gamma_5 u \mid 0\rangle\langle \pi^- \mid \overline{u} b \mid B_d^0\rangle \\
&+ \langle K^+ \mid \overline{s} r_5 u \mid 0\rangle\langle \pi^- \mid \overline{u}\gamma_\mu b \mid B_d^0\rangle \Big) \ . \qquad (12)
\end{aligned}
$$

By the use of these equations, the decay amplitude of $B \to K\pi$ is given as follows:

$$
\begin{aligned}
\langle K^+\pi^- \mid H_{eff} \mid B_d^0\rangle &= \frac{G_F}{\sqrt{2}} \Big[-V_{ub}V_{cs}^{*}\left(\frac{1}{3}C_1 + C_2\right) a^{K\pi}(Q^2) - V_{tb}V_{ts}^{*}\Big(\frac{1}{3}C_3 a^{K\pi}(Q^2) \\
+C_4 a^{K\pi}(Q^2) &+ \frac{2}{3}C_5 b^{K\pi}(Q^2) + 2C_6 b^{K\pi}(Q^2) + \frac{\alpha_s}{3\pi} C_8 \frac{m_b}{q^2} c^{K\pi}(Q^2) \ \Big) \ \Big] \ , \qquad (13)
\end{aligned}
$$

where

$$
\begin{aligned}
a^{K\pi}(Q^2) &\equiv \langle K^+ \mid \overline{s}\gamma_\mu\gamma_5 u \mid 0\rangle\langle \pi^- \mid \overline{u}\gamma^\mu b \mid B_d^0\rangle \ , \\
b^{K\pi}(Q^2) &\equiv \langle K^+ \mid \overline{s}\gamma_5 u \mid 0\rangle\langle \pi^- \mid \overline{u} b \mid B_d^0\rangle \ , \qquad (14) \\
c^{K\pi}(Q^2) &\equiv q^\mu \Big(\langle K^+ \mid \overline{s}\gamma_\mu\gamma_5 u \mid 0\rangle\langle \pi^- \mid \overline{u} b \mid B_d^0\rangle + \langle K^+ \mid \overline{s}\gamma_5 u \mid 0\rangle\langle \pi^- \mid \overline{u}\gamma_\mu b \mid B_d^0\rangle \Big) \ .
\end{aligned}
$$

The hadronic matrix elements $a^{K\pi}$, $b^{K\pi}$ and $c^{K\pi}$ are given in terms of the decay constant $f_K = 161\mathrm{MeV}$ and the longitudinal form factor $F_0^{B\pi}(Q^2)$ as

$$\begin{aligned} a^{K\pi}(Q^2) &= f_K(m_B^2 - m_\pi^2)F_0^{B\pi}(Q^2) \ , \\ b^{K\pi}(Q^2) &= \frac{m_K^2}{(m_s+m_u)(m_b-m_u)} a^{K\pi}(Q^2) \ , \\ c^{K\pi}(Q^2) &= \left[\frac{m_B^2 - m_K^2}{2(m_b-m_u)} + \frac{m_K^2}{m_s+m_u}\frac{m_B^2}{m_B^2-m_\pi^2}\right] a^{K\pi}(Q^2) \ , \end{aligned} \tag{15}$$

where f_K and the relevant form factors are defined by

$$\langle K^+ \mid \overline{s}\gamma_\mu\gamma_5 u \mid 0\rangle = f_K Q_\mu \ , \tag{16}$$

$$\langle \pi^- \mid \overline{u}\gamma_\mu b \mid B_d^0\rangle = \left(p_B + p_\pi - \frac{m_B^2 - m_\pi^2}{Q^2}Q\right)_\mu F_1^{B\pi}(Q^2) + \frac{m_B^2 - m_\pi^2}{Q^2} Q_\mu F_0^{B\pi}(Q^2) \ ,$$

with $Q = p_B - p_\pi$ and then with $Q^2 = m_K^2$. In the estimation of $b^{K\pi}$ and $c^{K\pi}$, the equations of motion are used for quarks and anti-quarks. Then, the decay branching ratio is obtained by calculating

$$BR(B_d^0 \to K^+\pi^-) = \tau_B \frac{p_\pi}{8\pi m_B^2} \mid \langle K^+\pi^- \mid H_{eff} \mid B_d^0\rangle \mid^2 \ . \tag{17}$$

The decay amplitude of $B \to \pi\pi$ is given in the same way,

$$\begin{aligned} \langle \pi^+\pi^- \mid H_{eff} \mid B_d^0\rangle &= \frac{G_F}{\sqrt{2}} \left[-V_{ub}V_{cd}^*\left(\frac{1}{3}C_1 + C_2\right) a^{\pi\pi}(Q^2) - V_{tb}V_{td}^*\left(\frac{1}{3}C_3 a^{\pi\pi}(Q^2)\right.\right. \\ +C_4 a^{\pi\pi}(Q^2) &+ \left.\left.\frac{2}{3}C_5 b^{\pi\pi}(Q^2) + 2C_6 b^{\pi\pi}(Q^2) + \frac{\alpha_s}{3\pi}C_8\frac{m_b}{q^2}c^{\pi\pi}(Q^2)\right)\right] \ , \end{aligned} \tag{18}$$

where

$$\begin{aligned} a^{\pi\pi}(Q^2) &= f_\pi(m_B^2 - m_\pi^2)F_0^{B\pi}(Q^2) \ , \\ b^{\pi\pi}(Q^2) &= \frac{m_\pi^2}{(m_d+m_u)(m_b-m_u)} a^{\pi\pi}(Q^2) \ , \\ c^{\pi\pi}(Q^2) &= \left[\frac{m_B^2 - m_\pi^2}{2(m_b-m_u)} + \frac{m_\pi^2}{m_d+m_u}\frac{m_B^2}{m_B^2-m_\pi^2}\right] a^{\pi\pi}(Q^2) \ , \end{aligned} \tag{19}$$

with $Q^2 = m_\pi^2$ and $f_\pi = 132\mathrm{MeV}$.

In the calculation of eqs.(15)and (19), we used the following approximations:

$$F_0^{B\pi}(m_K^2) \simeq F_0^{B\pi}(m_\pi^2) \simeq F_0^{B\pi}(0) = F_1^{B\pi}(0) \ , \tag{20}$$

which are satisfied within the errors of a few percent in the pole dominance model of the form factor[13]. In our numerical calculations, we use the quark mass parameters as [14] $m_b = 4.58$GeV or 5.12GeV, $m_c = 1.45$GeV, $m_s = 160$MeV, $m_u = 5.7$MeV and $m_d = 8.7$MeV.

Now we have left with only one unknown parameter $F_0^{B\pi}(0)$ in the $B \to K\pi$ and $B \to \pi\pi$ decay amplitudes except for the top-quark mass and the CP violating phase in the KM matrix. Then, we can predict the ratio of these decay branching ratios being independent of the form factor for the fixed phase ϕ, which is defined as $V_{ub} =\mid V_{ub} \mid \exp(-i\phi)$. This ratio is almost free from the factorization assumption, because the ambiguity of this approximation cancels each other in the numerator and the denominator. We show the predicted ratio versus ϕ in the case of $m_b = 4.58$GeV and 5.12GeV with $m_t = 140$GeV in fig.1. Our result changes only 4% in the region $m_t = 120 \sim 180$GeV. However, our result drastically depends on the value of $\mid V_{ub}/V_{cb} \mid$ as shown in fig.1, where we use the experimental value $\mid V_{ub}/V_{cb} \mid = 0.08 \pm 0.02$[7] with $\mid V_{cb} \mid = 0.045$.

fig.1

In order to know the contribution of the penguin process, we give the ratios of the penguin amplitudes to the tree amplitudes in the case of $\phi = 90°$, $m_b = 4.58$GeV and $m_t = 140$GeV for both $B \to K\pi$ and $B \to \pi\pi$ processes as follows:

$$\left| \frac{A(\text{penguin})}{A(\text{tree})} \right| = \begin{cases} 4.22 \times \left(\frac{0.08}{|V_{ub}/V_{cb}|}\right) & \text{for } B \to K\pi \\ 0.22 \times \left(\frac{0.08}{|V_{ub}/V_{cb}|}\right) & \text{for } B \to \pi\pi \end{cases} \quad . \tag{21}$$

The penguin process dominates the $B \to K\pi$ decay, but the tree process is not negligible. On the other hand, the tree process gives main contributions to the $B \to \pi\pi$ decay, although the penguin process is still sizable.

Since the experimentally observed branching ratio of $B \to \pi\pi + K\pi$ was given as shown in eq.(1), we can get the information of the form factor $F_0^{B\pi}(0)$ for the fixed $\mid V_{ub}/V_{cb} \mid$ and ϕ. We show the branching ratio versus $F_0^{B\pi}(0)$ for $\phi = 90°$ and $30°$ in fig.2. The experimental allowed region of the branching ratio is the one between the two horizontal dashed-lines in fig.2. Then, we obtain $F_0^{B\pi}(0) = 0.26 \sim 0.55$, which is consistent with the one in the BSW model, $F_0^{B\pi}(0) = 0.33$[13].

fig.2

We comment on the contribution of the charged Higgs boson in the THDM as a typical new physics candidate. In contrast with the case of the $B \to X_s\gamma$ decay, the charged Higgs contribution cannot provide so sizable enhancement on the $B \to K\pi$ decays. This conclusion is in agreement with the one in the case of $B \to K_X\phi$ in our previous paper [5]. Our predicted branching ratio increases only in the magnitude of around 10% for the case of $m_H = 300$GeVand $\cot\beta = 1$, which follow from the experimental upper bound of the $B \to X_s\gamma$ decay [5].

In the above analyses, we have neglected the final state interaction, which possibly affects the decay widths. The phase shifts due to the strong final state interactions have an effect on the magnitudes of the $B \to K\pi$ and $B \to \pi\pi$ decay amplitudes. First decomposing their purely weak (this means "without the final state interaction") amplitudes according to the the final state iso-spins and introducing the corresponding strong phase factor for each iso-spin amplitude, we obtain the physical decay amplitudes including the final state interaction. Then, we can readily rewrite, the physical decay amplitudes of $B \to K^+\pi^-$ in terms of the purely weak amplitudes of $B_d^0 \to K^+\pi^-$ and $B_d^0 \to K^0\pi^0$ as

$$\begin{aligned} \langle K^+\pi^- \mid H_{eff} \mid B_d^0\rangle^{phys} &= e^{-i\delta_{1/2}}\left\{\frac{1}{3}(2+e^{i\delta_{K\pi}})\langle K^+\pi^- \mid H_{eff} \mid B_d^0\rangle^{weak}\right. \\ &+ \left.\frac{\sqrt{2}}{3}(e^{i\delta_{K\pi}}-1)\langle K^0\pi^0 \mid H_{eff} \mid B_d^0\rangle^{weak}\right\} , \end{aligned} \tag{22}$$

where $\delta_{K\pi} \equiv \delta_{1/2} - \delta_{3/2}$ and

$$\begin{aligned} \langle \pi^+\pi^- \mid H_{eff} \mid B_d^0\rangle^{phys} &= e^{-i\delta_0}\left\{\langle \pi^+\pi^- \mid H_{eff} \mid B_d^0\rangle^{weak}\right. \\ &+ \left.\frac{\sqrt{2}}{3}(e^{i\delta_{\pi\pi}}-1)\langle \pi^+\pi^0 \mid H_{eff} \mid B_d^0\rangle^{weak}\right\} , \end{aligned} \tag{23}$$

where $\delta_{\pi\pi} \equiv \delta_0 - \delta_2$. However, the narrow resonances coupled to the $K\pi$ and $\pi\pi$ states are not expected at the energy scale of m_b. So, the large phase shifts are unlikely. Thus, our numerical results are not expected to be largely changed by the final state interaction.

The summary is given as follows. We have studied the penguin effect of the $B \to K\pi$ and $B \to \pi\pi$ decays considering the recent observed decay branching ratio by CLEO. We have predicted the ratio of these decay widths, which crucially depends on the CP violating phase ϕ and the still ambiguous KM matrix element $\mid V_{ub} \mid$. The experimental information of the $K\pi/\pi\pi$ ratio will serve us these important parameters in the SM model. Furthermore, the determination of the form factor will test many models of B meson decays. We expect that the K-π separation of the B meson decays will be done in the near future.

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Figure Captions

figure 1: The predicted ratios of $BR(B_d^0 \to K^+\pi^-)/BR(B_d^0 \to \pi^+\pi^-)$ versus the phase ϕ for $\mid V_{ub}/V_{cb} \mid = 0.06, 0.08$ and 0.10. The solid- and the dashed-lines correspond to the predictions in the case of $m_b = 4.58$ and 5.12GeV with $m_t = 140$GeV, respectively.

figure 2: The summed branching ratios of $BR(B_d^0 \to K^+\pi^-)$ and $BR(B_d^0 \to \pi^+\pi^-)$ versus the form factor $F_0^{B\pi}(0)$ for $\mid V_{ub}/V_{cb} \mid = 0.06, 0.08$ and 0.10, being fixed $m_b = 4.58$GeV and $m_t = 140$GeV. The solid- and the dashed-lines correspond to the predictions in the case of $\phi = 90°$ and $30°$, respectively. The upper bound and the lower one of the observed branching ratio are denoted by the two horizontal dashed-lines.