PHYSICAL REVIEW D **82,** 031502(R) (2010)

Enhanced B_s–$\bar{B}_s$ lifetime difference and anomalous like-sign dimuon charge asymmetry from new physics in $B_s \to \tau^+\tau^-$

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(Received 3 June 2010; published 18 August 2010)

New physics models that increase the decay rate of $B_s \to \tau^+\tau^-$ contribute to the absorptive part of B_s–$\bar{B}_s$ mixing, and may enhance $\Delta\Gamma_s$ all the way up to its current experimental bound. In particular, the model with a scalar leptoquark can lead to a significant violation of the expectation $\Delta\Gamma_s \leq \Delta\Gamma_s$ (SM). It can even allow regions in the $\Delta\Gamma_s$–β_s parameter space that are close to the best fit obtained by CDF and D0 through $B_s \to J/\psi\phi$. In addition, it can help explain the anomalous like-sign dimuon charge asymmetry observed recently by D0. A measurement of BR($B_s \to \tau^+\tau^-$) is thus crucial for a better understanding of new physics involved in B_s–$\bar{B}_s$ mixing.

DOI: 10.1103/PhysRevD.82.031502 PACS numbers: 14.40.Nd, 12.60.−i, 13.20.He, 13.25.Hw

I. INTRODUCTION

In the standard model (SM), the Cabbibo-Kobayashi-Maskawa (CKM) mixing matrix is the only source of charge-parity (*CP*) violation. The data from the decays of K, D, and B mesons have so far been consistent with this paradigm; however, the flavor-changing neutral current (FCNC) processes involving $b \to s$ transitions are expected to be sensitive to many sources of new physics (NP) [1]. This is why the B_s meson is one of the most important and interesting portals for indirect detection of such NP models.

In this paper, we shall concentrate on the oscillation parameters in the B_s–$\bar{B}_s$ system. The average decay width $\bar{\Gamma}_s \equiv (\Gamma_{sH} + \Gamma_{sL})/2 = (0.679^{+0.013}_{-0.011})\ \text{ps}^{-1}$ and the mass difference $\Delta M_s \equiv M_{sH} - M_{sL} = (17.77 \pm 0.10 \pm 0.07)\ \text{ps}^{-1}$ have already been measured to an accuracy of better than $\sim 2\%$ [2–4] and play an important role in constraining any NP. Here, the labels L and H stand, respectively, for the light and heavy mass eigenstates in the neutral B_s system. The decay width difference $\Delta\Gamma_s \equiv \Gamma_{sL} - \Gamma_{sH}$ and the B_s–$\bar{B}_s$ mixing phase are relatively less certain. The SM predictions for these quantities are [5]

$$\Delta\Gamma_s^{\rm SM} = (0.096 \pm 0.039)\ \text{ps}^{-1}, \tag{1}$$

$$\beta_s^{J/\psi\phi(\rm SM)} = \arg\left(-\frac{V_{cb}V_{cs}^*}{V_{tb}V_{ts}^*}\right) \approx 0.019 \pm 0.001, \tag{2}$$

where $2\beta_s^{J/\psi\phi}$ is the mixing phase relevant for $B_s \to J/\psi\phi$ decay. The recent CDF and D0 measurements [6,7], using the angular analysis in $B_s \to J/\psi\phi$ decay [8,9], give [10]

$$\Delta\Gamma_s = \pm(0.154^{+0.054}_{-0.070})\ \text{ps}^{-1}, \tag{3}$$

$$\beta_s^{J/\psi\phi} = (0.39^{+0.18}_{-0.14}) \cup (1.18^{+0.14}_{-0.18}), \tag{4}$$

where the second set in the last line is just the complement of $\pi/2$ for the first set. This reflects the ambiguity in the determination of $\beta_s^{J/\psi\phi}$. Note that the sign of $\Delta\Gamma_s$ is undetermined. The positive and negative signs correspond, respectively, to the two disconnected regions in the allowed parameter space for $\beta_s^{J/\psi\phi}$. Alternative ways of removing this sign ambiguity have been suggested in [11]. The correlated constraints are shown in Fig. 1. The SM prediction for $(\Delta\Gamma_s, \beta_s^{J/\psi\phi})$ is excluded by the data to 90% C.L. Hence, the exploration of NP effects on these quantities becomes imperative.

While many NP models can affect $\beta_s^{J/\psi\phi}$ and make its value anywhere in its conventional allowed range $[-\pi/2, \pi/2]$, the ability of NP to influence $\Delta\Gamma_s$ is rather limited. Indeed, the width difference is

$$\Delta\Gamma_s = 2|\Gamma_{12s}|\cos\phi_s, \tag{5}$$

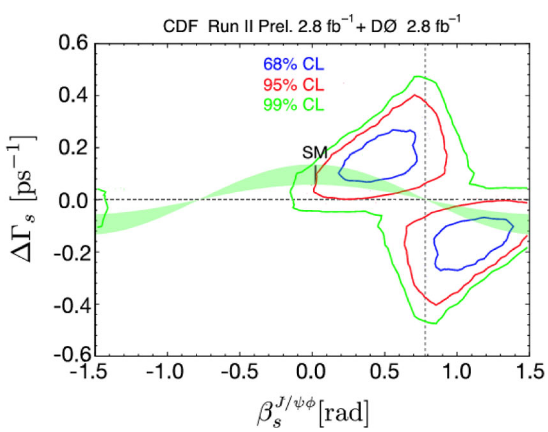

FIG. 1 (color online). The combined experimental constraints by CDF and D0 through $B_s \to J/\psi\phi$. Blue, red, and green contours (from inner to outer) correspond to the 68%, 95%, and 99% C.L. regions. The sinusoidal green band corresponds to the relation $\Delta\Gamma_s \approx \Delta\Gamma_s^{\rm SM}\cos\phi_s$, valid when NP does not contribute to Γ_{12s}. The figure is taken from [7].

where $\phi_s \equiv \arg(-M_{12s}/\Gamma_{12s})$. Here M_{12s} and Γ_{12s} are the dispersive and absorptive parts, respectively, of the B_s–$\bar{B}_s$ mixing amplitude. In the SM [5],

$$\phi_s = 0.0041 \pm 0.0007, \tag{6}$$

and hence $\Delta\Gamma_s^{\rm SM} \approx 2|\Gamma_{12s}|$. The class of NP models which do not affect Γ_{12s} then satisfy $\Delta\Gamma_s \leq \Delta\Gamma_s^{\rm SM}$ [12]. These include the minimal flavor-violating models [13] where the bases in the quark flavor space are the same as that in the SM, as well as models where the mixing box diagram contains only heavy degrees of freedom. The predictions of these models for ($\Delta\Gamma_s$, $\beta_s^{J/\psi\phi}$) will then be restricted to the sinusoidal band shown in Fig. 1. Note that only a small part of this band is within the 68% C.L. region, so that NP of this type will be unable to account for the measurements if the errors decrease with the best-fit values staying unchanged.

However, there are well-motivated models where the B_s–$\bar{B}_s$ mixing box diagram contains two light degrees of freedom, resulting in an absorptive amplitude. Given the current strong constraints on the B_s decays to hadrons, e^+e^- and $\mu^+\mu^-$ [2], the only candidate for the intermediate light particle is τ. In an earlier publication [14], we had implemented this idea with two examples: (i) the model with a scalar leptoquark (LQ), and (ii) R parity-violating supersymmetry. These models can have *flavor-dependent* couplings of a light particle with a heavy new particle—in particular, τ can couple with the LQ or squark—and hence can contribute to Γ_{12s}. A significant enhancement of $\Delta\Gamma_s$ was shown to be possible in the former model [14]. In this paper, we shall investigate the effect of the LQ on the correlation between $\Delta\Gamma_s$ and $\beta_s^{J/\psi\phi}$, keeping in mind that any such NP will also significantly affect the decay rate $B_s \to \tau^+\tau^-$.

Recently, the D0 Collaboration has claimed evidence for an anomalous like-sign dimuon charge asymmetry [15]

$$A_{\rm sl}^b = -0.009\,57 \pm 0.002\,51 \pm 0.001\,46. \tag{7}$$

CDF has also measured the same quantity using 1.6 fb^{-1} of data and found $A_{\rm sl}^b = (8.0 \pm 9.0 \pm 6.8) \times 10^{-3}$ [16]. Combining these two, one gets

$$A_{\rm sl}^b = -(8.5 \pm 2.8) \times 10^{-3}, \tag{8}$$

which differs from the SM prediction

$$A_{\rm sl}^{b({\rm SM})} = -0.000\,23^{+0.000\,05}_{-0.000\,06} \tag{9}$$

by about 3σ. Such an asymmetry can be used as a probe of the flavor structure of NP [17]. It turns out that the same NP that enhances $\Delta\Gamma_s$ can also help in explaining this anomaly. We shall elaborate on this in the latter part of this paper.

II. NEW PHYSICS IN $B_s \to \tau^+\tau^-$

LQs are color-triplet objects that couple to quarks and leptons. They occur generically in grand unified theories [18], composite models [19], and superstring-inspired E_6 models [20]. Model-independent constraints on their properties are available [21], and the prospects of their discovery at the LHC have also been studied [22].

The direct production limits depend on the LQ model, as well as the SM fermions these LQs can couple to. The bounds on the second- and third-generation LQs are, respectively, $M_{\rm LQ} > 316$ and 245 GeV, when they are pair produced [2,23]. A third-generation scalar LQ decaying only into a b quark and a τ lepton has a mass bound of 210 GeV [24]. We shall conservatively take $M_{\rm LQ} =$ 250 GeV in this analysis. However, our results hold even with much higher $M_{\rm LQ}$, by appropriately scaling the coupling $|h_{\rm LQ}|$ as shall be seen later.

We shall restrict ourselves to scalar LQs that are singlets under the SU$(2)_L$ gauge group of the SM. This is because vector or most of the SU$(2)_L$ nonsinglet LQs tend to couple directly to neutrinos, hence we expect that their couplings are tightly constrained from the neutrino mass and mixing data. This makes any significant effect on the B_s–$\bar{B}_s$ system unlikely.

The relevant interaction term for a scalar SU$(2)_L$ singlet leptoquark is of the form

$$\mathcal{L}_{\rm LQ} = \lambda_{ij}\bar{d}^c_{jR}e_{iR}\mathcal{S}_0 + {\rm H.c.}, \tag{10}$$

where d_R and e_R stand for the right-handed down-type quarks and right-handed charged leptons, respectively, and i, j are generation indices that run from one to three. The couplings λ_{ij} can in general be complex, and some of them may vanish depending on any flavor symmetries involved. We take the LQ couplings in the quark mass basis. This is the most economical choice given the fact that we do not know the rotation matrix for the right-chiral down-type quark fields. One can also have an SU$(2)_L$ doublet LQ, whose interaction is of the form

$$\mathcal{L}_{\rm LQ} = \lambda_{ij}\bar{q}_{jL}i\sigma_2 e_{iR}\mathcal{S}_{(1/2)} + {\rm H.c.}, \tag{11}$$

which gives almost identical results.

When λ_{32} and λ_{33} are nonzero, the interaction in Eq. (10) generates an effective four-fermion $(S+P)\otimes(S+P)$ interaction, leading to $b \to s\tau^+\tau^-$. This will contribute to B_s–$\bar{B}_s$ mixing (with τ and $\mathcal{S}_0$ flowing inside the box), to the leptonic decay $B_s \to \tau^+\tau^-$, and to the semileptonic decays $B \to X_s\tau^+\tau^-$. The relevant quantity here is the coupling product

$$h_{\rm LQ}(b \to s\tau^+\tau^-) \equiv \lambda_{32}^*\lambda_{33}. \tag{12}$$

One may get a tight constraint on $|h_{\rm LQ}|$ from $B_s \to \tau^+\tau^-$. One expects the lifetimes of B_d and B_s to be the same in the SM: $\tau_{B_s}/\tau_{B_d} = 1.00 \pm 0.01$ [2]. This is certainly true if we assume spectator dominance: the decays which do not have a spectator quark contribute negligibly in the total decay width. Experimentally, $\Gamma_s/\Gamma_d - 1 = (3.6 \pm 1.8)\%$ [10]. Thus, the branching ratio $\mathcal{B} \equiv {\rm BR}(B_s \to \tau^+\tau^-)$ can be as large as 6%–7%. Considering the deviations from the naive spectator model, which is expected to be small for the B_d and B_s systems, one may conservatively put the upper bound for $\mathcal{B}$ at 10%. The value of $\mathcal{B}$ is only $\mathcal{O}(10^{-8})$ in the SM. This decay has not been observed, nor is a direct measurement of an upper bound on its branching ratio available. A similar estimate of $\mathcal{B} \sim 5\%$ is available in [25]. If $|h_{\rm LQ}|$ is indeed large enough to cause such a significant enhancement in $\mathcal{B}$, it is related to $\mathcal{B}$ directly through

$$\mathcal{B} \approx \frac{|h_{\rm LQ}|^2}{128\pi M_{\rm LQ}^4}\frac{f_{B_s}^2 M_{B_s}^3}{\bar{\Gamma}_s}\frac{m_\tau^2}{M_{B_s}^2}\sqrt{1-4\frac{m_\tau^2}{M_{B_s}^2}} \approx 9.5\%\left(\frac{|h_{\rm LQ}|}{0.3}\right)^2\left(\frac{250\ {\rm GeV}}{M_{\rm LQ}}\right)^4\left(\frac{f_{B_s}}{0.250\ {\rm GeV}}\right), \qquad (13)$$

where f_{B_s} is the B_s decay constant. It can be seen that for $M_{\rm LQ} = 250$ GeV, $\mathcal{B} \approx 10\%$ can accommodate $|h_{\rm LQ}| \approx 0.3$.

We shall show in the next sections that the values of $|h_{\rm LQ}|$ allowed by the above analysis can cause significant changes in the values of $\Delta\Gamma_s$ and $\beta_s^{J/\psi\phi}$, and can also enhance $A_{\rm sl}^b$ by a sizable amount.

III. NEW PHYSICS IN $\Delta\Gamma_s$ AND $\beta_s^{J/\psi\phi}$

In the presence of NP contribution, the expressions for the dispersive and absorptive parts of B_s–$\bar{B}_s$ mixing can be written as

$$M_{12s} = M_{12s}^{\rm SM} + M_{12s}^{\rm LQ} = M_{12s}^{\rm SM} R_M e^{i\phi_M}, \qquad (14)$$

$$\Gamma_{12s} = \Gamma_{12s}^{\rm SM} + \Gamma_{12s}^{\rm LQ} = \Gamma_{12s}^{\rm SM} R_\Gamma e^{i\phi_\Gamma}. \qquad (15)$$

The SM contributions, to leading order (LO) in $1/m_b$ and $\alpha_s(m_b)$, are given by [26,27]

$$M_{12s}^{\rm SM} = (V_{tb}V_{ts}^*)^2 \frac{G_F^2}{12\pi^2}\chi_{B_s}\hat{\eta}_{B_s} M_W^2 S_0(x_t), \qquad (16)$$

$$\Gamma_{12s}^{\rm SM} = -[(V_{cb}V_{cs}^*)^2\Gamma^{cc} + (V_{ub}V_{us}^*)^2\Gamma^{uu} + 2(V_{cb}V_{cs}^*V_{ub}V_{us}^*)\Gamma^{cu}], \qquad (17)$$

where $\chi_{B_s} \equiv M_{B_s}B_{B_s}f_{B_s}^2$, and Γ^{ij}, the absorptive parts of the box diagrams (without the CKM factors) with quarks i and j flowing inside the loop are given in [5]. The short distance behavior is contained in $\hat{\eta}_{B_q}$, which incorporates the QCD corrections, and in the Inami-Lim function $S_0(x_t)$. The value of $\Gamma_{12s}^{\rm SM}$ has been calculated up to $\mathcal{O}(1/m_b^2)$ in [28], wherein some NP contributions to $\Delta\Gamma_s$ have also been studied.

The LO LQ contributions to the above quantities are [14]

$$M_{12s}^{\rm LQ} = \frac{h_{\rm LQ}^2}{384\pi^2 M_{\rm LQ}^2}\chi_{B_s}\hat{\eta}_{B_s}\tilde{S}_0(x_\tau), \qquad (18)$$

$$\Gamma_{12s}^{\rm LQ(0)} = -\frac{h_{\rm LQ}^2}{256\pi M_{\rm LQ}^4}\chi_{B_s} m_b^2 F(\tau), \qquad (19)$$

where $\tilde{S}_0(x_\tau)$ is another Inami-Lim function, and the phase space factor is $F(\tau) = 0.64$. The details of the calculation may be found in [14].

While the next to leading order QCD corrections and the $1/m_b$ corrections do not affect $M_{12s}^{\rm SM}$ significantly, they modify $\Gamma_{12s}^{\rm SM}$ by $\sim$30% from its LO value [29]. The QCD corrections are expected to be different for SM and LQ operators, since the mediating heavy particle for the latter case is a color triplet. The $1/m_b$ corrections are also expected to differ, since the light degrees of freedom that flow inside the mixing box are different too. While it is desirable to have an idea of these corrections, since we are only showing typical results from allowed LQ parameters, such corrections can be absorbed by just changing the value of $M_{\rm LQ}$ and the phase of $h_{\rm LQ}$. Therefore, in our numerical analysis, we use the SM predictions for $\Gamma_{12s}^{\rm SM}$ [5] that include the next-to-leading-order (NLO) QCD and $1/m_b$ corrections; however, for $\Gamma_{12s}^{\rm LQ}$ we only use the LO contribution. For the sake of clarity, while calculating the combined SM and LQ contribution to Γ_{12s}, we use only the central value of the SM prediction. Including the 30% error in the SM prediction will widen the bands for our results shown in Fig. 2.

In the presence of LQs, Eqs. (5), (14), and (15) lead us to write the width difference as

$$\Delta\Gamma_s = 2|\Gamma_{12s}^{\rm SM}|R_\Gamma\cos(\phi_M - \phi_\Gamma - 2\beta_s^{\rm SM}) \approx \Delta\Gamma_s^{\rm SM}R_\Gamma\cos(\phi_M - \phi_\Gamma), \qquad (20)$$

where the approximation uses $\beta_s^{\rm SM} \approx 0$. The allowed values of $h_{\rm LQ}$ permit $R_\Gamma\cos(\phi_M - \phi_\Gamma) > 1$, so that the value of $\Delta\Gamma_s$ can be enhanced in this model. Figure 2 shows that the enhancement can be even up to $\Delta\Gamma_s \approx 0.4$ ps^{-1} for $|h_{\rm LQ}| \approx 0.3$.

The decay $B_s \to J/\psi\phi$ exhibits CP violation through the interference of mixing and decay. The CP violating phase measured through the time-dependent angular distribution of this decay is

$$\beta_s^{J/\psi\phi} \approx \frac{1}{2}\arg\left(-\frac{(V_{cb}V_{cs}^*)^2}{M_{12s}}\right) = \beta_s^{J/\psi\phi({\rm SM})} - \frac{\phi_M}{2}, \qquad (21)$$

where we have used the approximation $|\Gamma_{12s}| \ll |M_{12s}|$. Clearly, at low values of $|h_{\rm LQ}|$, the allowed range of ϕ_M will be restricted to be near zero, and hence $\beta_s^{J/\psi\phi}$ will be close to its SM value, which itself is close to zero. For higher $|h_{\rm LQ}|$, however, the value of ϕ_M can be anything, and hence $\beta_s^{J/\psi\phi}$ can be anywhere in its conventional range $[-\pi/2, \pi/2]$. This is illustrated in Fig. 2.

Figure 2 overlays our predictions with the LQ model in the $\Delta\Gamma_s$–$\beta_s^{J/\psi\phi}$ plane on the results of the combined analysis of CDF and D0. Clearly, the additional LQ contribution not only can enhance $\Delta\Gamma_s$ and β_s, but also can allow us to be well within the 68% C.L. region of the current best fit.

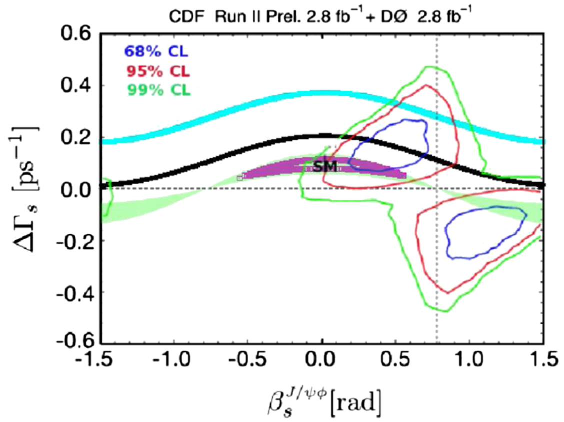

FIG. 2 (color online). The predictions of $(\Delta\Gamma_s, \beta_s^{J/\psi\phi})$ within the scalar leptoquark model, overlaid on the combined experimental constraints by CDF and D0 through $B_s \to J/\psi\phi$ (Fig. 1). Magenta (dark gray), black, and aqua (light gray) bands correspond to $|h_{\rm LQ}| = 0.07$, 0.17, and 0.27, respectively, with $M_{\rm LQ} = 250$ GeV.

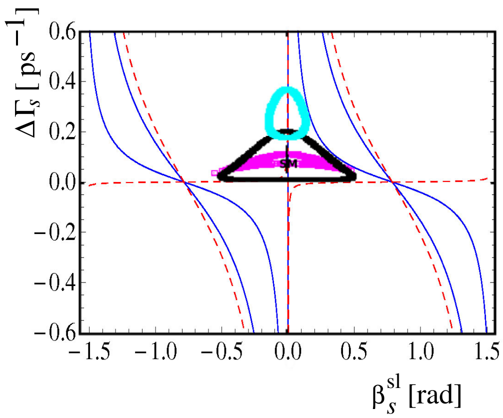

FIG. 3 (color online). The predictions for $(\Delta\Gamma_s, \beta_s^{\rm sl})$ within the scalar leptoquark model, overlaid on the 68% (continuous blue) and 95% (dashed red) C.L. contours for the combined D0 and CDF measurements of $a_{\rm sl}^s$. Magenta (dark gray), black, and aqua (light gray) bands correspond to $|h_{\rm LQ}| = 0.07$, 0.17, and 0.27, respectively, with $M_{\rm LQ} = 250$ GeV.

IV. NEW PHYSICS IN $A_{\rm sl}^b$

The like-sign dimuon charge asymmetry $A_{\rm sl}^b$ measured by D0 [15] and CDF [16] is related to the semileptonic decay asymmetries $a_{\rm sl}^d$ and $a_{\rm sl}^s$ in the B_d and B_s sectors, respectively, through [15]

$$A_{\rm sl}^b = (0.506 \pm 0.043) a_{\rm sl}^d + (0.494 \pm 0.043) a_{\rm sl}^s. \quad (22)$$

The coefficients here are valid even in the presence of NP. The average $A_{\rm sl}^b$ from Eq. (8) and the current experimental constraints of $a_{\rm sl}^d = -0.0047 \pm 0.0046$ [10] yield

$$a_{\rm sl}^s = -0.012 \pm 0.007, \quad (23)$$

which is almost 2σ away from the SM prediction [5]

$$a_{\rm sl}^{s({\rm SM})} = (2.1 \pm 0.6) \times 10^{-5}. \quad (24)$$

This quantity is directly related to $\Delta\Gamma_s$ and the B_s–$\bar{B}_s$ mixing phase via

$$a_{\rm sl}^s = \frac{\Delta\Gamma_s}{\Delta M_s} \tan\phi_s^{\rm sl} = -\frac{\Delta\Gamma_s}{\Delta M_s} \tan 2\beta_s^{\rm sl}, \quad (25)$$

where $\phi_s^{\rm sl} \equiv \arg(-M_{12s}/\Gamma_{12s}) = \phi_s$ and we have defined $\beta_s^{\rm sl}$ such that $\phi_s^{\rm sl} = -2\beta_s^{\rm sl}$. From Eq. (6), we have

$$\beta_s^{\rm sl} = -0.0020 \pm 0.0003. \quad (26)$$

In the presence of NP that affects Γ_{12s}, Eqs. (14) and (15) yield the relation

$$\beta_s^{\rm sl} = \frac{1}{2} \arg\left(-\frac{\Gamma_{12s}}{M_{12s}}\right) = \beta_s^{\rm sl(SM)} - \frac{\phi_M}{2} + \frac{\phi_\Gamma}{2}. \quad (27)$$

Since $\beta_s^{J/\psi\phi({\rm SM})} \approx 0 \approx \beta_s^{\rm sl(SM)}$, Eqs. (21) and (27) clearly show that $\beta_s^{\rm sl}$ is in general different from $\beta_s^{J/\psi\phi}$. Note that when NP does not affect Γ_{12s}, the value of ϕ_Γ vanishes and only then can one say $\beta_s^{\rm sl} \approx \beta_s^{J/\psi\phi}$. Therefore, it is not recommended to superimpose the parameter spaces of $(\Delta\Gamma_s, \beta_s^{\rm sl})$ and $(\Delta\Gamma_s, \beta_s^{J/\psi\phi})$.

In Fig. 3, we show the constraints in the $(\Delta\Gamma_s, \beta_s^{\rm sl})$ parameter space coming from the $A_{\rm sl}^b$ (consequently, $a_{\rm sl}^s$) measurement in [15], and also show $(\Delta\Gamma_s, \beta_s^{\rm sl})$ predictions at some allowed $|h_{\rm LQ}|$ values. It shows that the LQ contribution can give rise to $a_{\rm sl}^s$ values well within the 95% C.L. region of the experimental data. Note that the predictions shown in Figs. 2 and 3 correspond to the same set of NP parameters. This again illustrates the need to clearly differentiate between $\beta_s^{\rm sl}$ and $\beta_s^{J/\psi\phi}$.

V. SUMMARY AND CONCLUSIONS

The model with a scalar LQ, presented in this paper, belongs to the special class of NP models that affect the absorptive part Γ_{12s} of B_s–$\bar{B}_s$ mixing. It can therefore evade the relation $\Delta\Gamma_s < \Delta\Gamma_s^{\rm SM}$ and can give enhanced values of the lifetime difference in the B_s–$\bar{B}_s$ system. The enhancement in $\Delta\Gamma_s$ also corresponds to an enhancement in the branching ratio ${\rm BR}(B_s \to \tau^+\tau^-)$.

Recent measurements of $\Delta\Gamma_s$ and $\beta_s^{J/\psi\phi}$ by the CDF and D0 Collaborations exclude the SM prediction to 90% C.L. We illustrate with the example of the scalar LQ model that $\Delta\Gamma_s$ as large as 0.4 ps^{-1} may be achieved, and values in the $(\Delta\Gamma_s, \beta_s^{J/\psi\phi})$ parameter space close to the best fit from these measurements can be obtained. Indeed, if future experiments decrease the errors on these quantities while keeping the best-fit values at their current positions, only models belonging to this class will be able to explain the deviation from the SM.

The explanation of anomalous like-sign dimuon charge asymmetry recently observed at D0 is also facilitated by this class of models, since these models give rise to large $\Delta\Gamma_s$ as well as large $\beta_s^{\rm sl}$ simultaneously. We point out that these models in general imply that $\beta_s^{\rm sl} \neq \beta_s^{J/\psi\phi}$, so one has to be careful when including NP in the analysis. Also, note that this mechanism affects $A_{\rm sl}^b$ through the modification of $\Delta\Gamma_s$ and ϕ_s, without the need of an explicit $b \to s\mu^+\mu^-$ coupling. This is a common feature of all models which have an absorptive part in the B_s–$\bar{B}_s$ mixing diagram.

In order to confirm the compatibility of such models with the data, one needs further NLO calculations of the predictions of these models, as well as a better measurement of $B_s \to \tau^+\tau^-$ branching ratio, which will be crucial to constrain the LQ couplings. The τ from $B_s \to \tau^+\tau^-$ may be expected to have enough energy boost at the LHC to be detected. The τ polarization can also be measured: the τ's coming from LQs are expected to be right-handed. In addition, if we have an $SU(2)_L$ doublet leptoquark $\mathcal{S}_{(1/2)}$, this will also give rise to the FCNC top decay $t \to c\tau^+\tau^-$ at the level of 1%, which will be another probe of the NP of this class.

ACKNOWLEDGMENTS

We thank the CDF and D0 Collaborations for allowing us to use Fig. 1. We thank B. Dobrescu and D. Hedin for pointing us toward the latest bounds on leptoquark masses, and A. Lenz for his clarification about various β_s phases. A. K. acknowledges CSIR, Government of India, and the DRS program of UGC, Government of India, for financial support. S. N. is supported in part by MIUR under Contract No. 2008H8F9RA_002 and by the EU's Marie Curie Research Training Network under Contract No. MRTN-CT-2006-035505, "Tools and Precision Calculations for Physics Discoveries at Colliders."

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