Implications of large dimuon CP asymmetry in Bs,d decays on minimal flavor violation with low tan beta

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arXiv:1007.1872

Dimuon Asymmetry

- The D0 collaboration has recently announced evidence for new CP violating physics in semileptonic B decays:

$$(a^b_{\rm SL})^{D0} \equiv \frac{N_b^{++} - N_b^{--}}{N_b^{++} + N_b^{--}} = (-9.6 \pm 2.5 \pm 1.5) \times 10^{-3}$$

- To be compared with the SM prediction:

$$(a^b_{\rm SL})^{\rm SM} = (-0.23^{+0.05}_{-0.06}) \times 10^{-3}.$$

3.2sigma effect

To explain the difference between the measurement and the SM prediction:

A new physics contribution in $B_s - \overline{B_s}$ and/or $B_d - \overline{B_d}$ mixing is required

Comparable in size with the SM and carrying a new phase of $\mathcal{O}(1)$

$$M_{12}^{d,s} = \left(M_{12}^{d,s}\right)^{\rm SM} \left(1 + h_{d,s}\, e^{2i\sigma_{d,s}}\right)$$

Minimal Flavor Violation (MFV)

Addresses the *New Physics Flavor Puzzle:*

Why does generic new physics not contribute orders of magnitude above the observed flavor changing neutral current process rates?

Answer: New physics carries no new sources of flavor violation beyond the Yukawa matrices of the SM

Wide class of models
(SUSY gauge mediation, anomaly mediation, extra dimensions, …)

(Can phrase in the language of spurions:

$$SU(3)_Q \times SU(3)_U \times SU(3)_D$$

$$Y_U \sim (3, \bar{3}, 1), \quad Y_D \sim (3, 1, \bar{3})$$
)

B-Meson Mixing

A complete set of four quark operators relevant for $B_s - \overline{B_s}$ transitions:

$$M_{12}^s \sim \langle \overline{B_s} | \mathcal{H}_{\rm eff}^{\Delta B = \Delta S = 2} | B_s \rangle$$

$$\mathcal{H}_{\rm eff}^{\Delta B = \Delta S = 2} = \frac{1}{\Lambda^2} \left(\sum_{i=1}^{5} z_i Q_i + \sum_{i=1}^{3} \tilde{z}_i \widetilde{Q}_i \right)$$

← MFV structure

$$\left(\begin{array}{lcl} Q_1^{sb} & = & \bar{b}_L^\alpha \gamma_\mu s_L^\alpha \bar{b}_L^\beta \gamma_\mu s_L^\beta, \quad \widetilde{Q}_1^{sb} = \bar{b}_R^\alpha \gamma_\mu s_R^\alpha \bar{b}_R^\beta \gamma_\mu s_R^\beta, \\ Q_2^{sb} & = & \bar{b}_R^\alpha s_L^\alpha \bar{b}_R^\beta s_L^\beta, \quad \widetilde{Q}_2^{sb} = \bar{b}_L^\alpha s_R^\alpha \bar{b}_L^\beta s_R^\beta, \\ Q_3^{sb} & = & \bar{b}_R^\alpha s_L^\beta \bar{b}_R^\beta s_L^\alpha, \quad \widetilde{Q}_3^{sb} = \bar{b}_L^\alpha s_R^\beta \bar{b}_L^\beta s_R^\alpha, \\ Q_4^{sb} & = & \bar{b}_R^\alpha s_L^\alpha \bar{b}_L^\beta s_R^\beta, \quad Q_5^{sb} = \bar{b}_R^\alpha s_L^\beta \bar{b}_L^\beta s_R^\alpha. \end{array} \right)$$

B-Meson Mixing and MFV

Down quark mass basis:

$$Y_d = \mathrm{diag}(y_d, y_s, y_b), \quad Y_u = V^\dagger \times \mathrm{diag}(y_u, y_c, y_t),$$

$$\frac{z_1}{y_t^4 (V_{ts} V_{tb}^*)^2} = r_1^+ - r_1^- y_b^2, \qquad \text{real}$$

$$\frac{z_{2,3}}{y_t^4 (V_{ts} V_{tb}^*)^2} = r_{2,3} (v^2/\Lambda^2) y_b^2, \qquad \text{complex}$$

$$\frac{z_{4,5}}{y_t^4 (V_{ts} V_{tb}^*)^2} = r_{4,5}^+ y_b y_s - r_{4,5}^- y_b^3 y_s \qquad \text{real}$$

B-Meson Mixing and MFV

In MFV with small y_b (low $\tan\beta = v_u/v_d$) a large contribution to B_s mixing comes solely from two operators $Q_{2,3}$

$$\frac{z_{2,3}}{y_t^4 (V_{ts} V_{tb}^*)^2} = r_{2,3} (v^2/\Lambda^2) y_b^2,$$

complex

Small y_b : Large phase only from here

Implications

- Constrains the scale of new physics:

  General: $\Lambda \lesssim 700$ TeV

  MFV: $\Lambda_{\rm MFV} \lesssim 30$ TeV

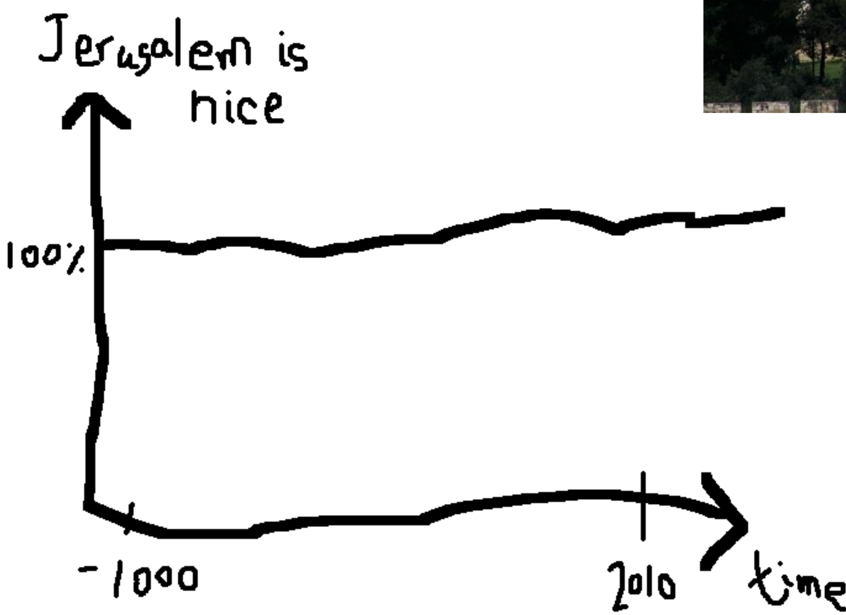
  MFV low $\tan\beta$: $\Lambda_{Q_2} \lesssim 260~{\rm GeV}~\sqrt{\tan\beta}$

- Supersymmetry:

  MFV with low $\tan\beta$ will be excluded!

gauge mediation,
anomaly mediation...

Predictive scenario (large effects on CPV observables: $S_{\psi K}$, $S_{\psi\phi}$)
Can check that EDMs and ϵ_K are not a problem
Probing MFV with the pattern of CP violation



THANKS!

$$\begin{aligned}\Delta m_q &= \Delta m_q^{\rm SM}\left|1+h_q e^{2i\sigma_q}\right|,\\ \Delta\Gamma_s &= \Delta\Gamma_s^{\rm SM}\cos\left[\arg\left(1+h_s e^{2i\sigma_s}\right)\right],\\ A_{\rm SL}^q &= {\rm Im}\left\{\Gamma_{12}^q/\left[M_{12}^{q,{\rm SM}}(1+h_q e^{2i\sigma_q})\right]\right\},\\ S_{\psi K} &= \sin\left[2\beta+\arg\left(1+h_d e^{2i\sigma_d}\right)\right],\\ S_{\psi\phi} &= \sin\left[2\beta_s-\arg\left(1+h_s e^{2i\sigma_s}\right)\right].\end{aligned}$$

$$\begin{aligned}\Delta m_q &\approx (1.0\pm 0.1)\Delta m_q^{\rm SM},\\ \Delta\Gamma_q &\approx (0.98^{+0.01}_{-0.02})\Delta\Gamma_q^{\rm SM},\\ a_{\rm SL}^q &\approx (0.22\pm 0.07)\left(\Gamma_{12}^q/M_{12}^q\right)^{\rm SM},\\ S_{\psi K} &\approx 0.65\pm 0.05,\\ S_{\psi\phi} &\approx 0.25\pm 0.06.\end{aligned}$$

$$\frac{a_{\rm SL}^s}{S_{\psi\phi}/(1-S_{\psi\phi}^2)^{1/2}} = -\frac{|\Delta\Gamma_s|}{\Delta m_s}$$

$$a_{\rm sl}^b \equiv \frac{\Gamma(\bar B\to\mu^+X)-\Gamma(B\to\mu^-X)}{\Gamma(\bar B\to\mu^+X)+\Gamma(B\to\mu^-X)} = A_{\rm sl}^b$$

$$\beta_s = \arg[-(V_{ts}V_{tb}^*)/(V_{cs}V_{cb}^*)] = (1.04\pm 0.05)^\circ$$

$$\beta = \phi_1 = \arg\left(-\frac{V_{cd}V_{cb}^*}{V_{td}V_{tb}^*}\right)$$

	$y_b \sim 1$			$y_b \ll 1$		
i	$S_{\psi\phi}$	$S_{\psi K}$	ϵ_K	$S_{\psi\phi}$	$S_{\psi K}$	ϵ_K
1	small	small	large	small	small	large
2,3	large	large	small	large	large	small
4,5	large	small	large	small	small	large