Phenomenology of a $U(2)^3$ flavour symmetry

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mainly based on:
Barbieri,Buttazzo,S,Straub arXiv:1203.4218 and 1206.1327

Motivations and Conclusions

Flavour: excellent agreement between data and CKM picture

In other words: $\Delta\mathcal{L} = \sum_i \frac{1}{\Lambda_i^2}\mathcal{O}_i \quad \Rightarrow \quad \boxed{\Lambda_i \gtrsim 10^3 \div 10^4\,\mathrm{TeV}}$

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with $c_i \sim O(1)$ and ξ_i small due to some **flavour symmetry**

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- ✓ $\xi \sim V_{CKM}^{2\div 4} \quad \Rightarrow \quad \boxed{\Lambda \sim \text{a few}\ \mathrm{TeV}}$ is OK with flavour bounds
- ✓ potentially rich phenomenology behind the corner
- ✓ other virtues...

Modelling $U(2)^3$ $= U(2)_{Q_L} \times U(2)_{U_R} \times U(2)_{D_R}$

Exact $U(2)^3 \quad \longrightarrow \quad m_u = m_d = m_s = m_c = 0,\ V_{CKM} = 1$

$$Y_u = y_t \left(\begin{array}{c|c} 0 & 0 \\ \hline 0 & 1 \end{array}\right) \qquad Y_d = y_b \left(\begin{array}{c|c} 0 & 0 \\ \hline 0 & 1 \end{array}\right)$$

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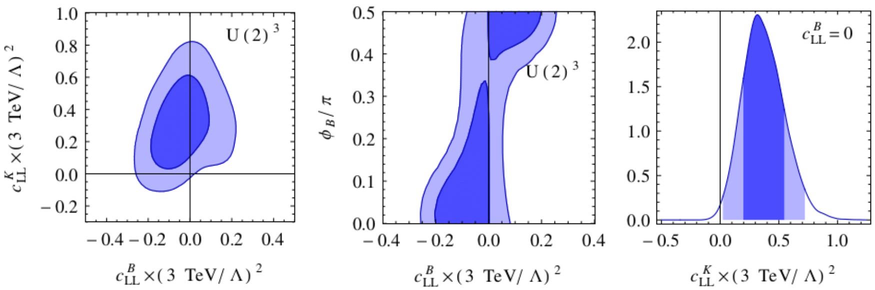
Assume: all flavour violation controlled by $\Delta Y_{u,d}$, V

i.e. $\Delta\mathcal{L}$ built with bilinears like $\quad \bar{\mathbf{q}}_{\mathbf{L}} V \gamma_\mu q_{3L}, \quad \bar{\mathbf{q}}_{\mathbf{L}} \Delta Y_d \mathbf{d}_{\mathbf{R}}$

Example: $\Delta\mathcal{L} \supset \dfrac{c_L^B e^{i\phi_B}}{\Lambda^2} (\mathbf{V_{tb} V_{ti}^*})^2 \, (\bar{d}_L^i \gamma_\mu b_L)^2, \quad i = d, s \qquad [B^0_{d,s} - \bar{B}^0_{d,s}]$

$\Delta F = 2$

Can solve CKM fit tensions!

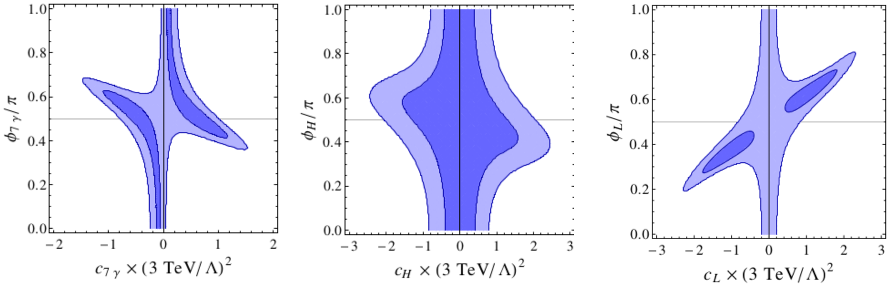


Messages

- Data consistent with $\Delta\mathcal{L} = \sum_i \xi_i \frac{c_i}{\Lambda_i^2}\mathcal{O}_i$ and $|c_i| = 0.2 \div 1$
- Larger effects than $U(3)^3$ allowed — see also [Buras, Girrbach 2012]

$U(3)^3$: Y_u, Y_d instead of $\Delta Y_{u,d}$, V — $c_L^B = c_L^K$ and $\phi_B = 0$

$\Delta F = 1$ $\qquad$ $b \to s(d)\ell\bar{\ell},\ b \to s(d)\nu\bar{\nu}$



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Final messages

How to know it is $U(2)^3$? (if some new physics signal seen)

- $s - d$ correlation in B decays (same as SM), with new phase
- no new phase in $K - \bar{K}$ mixings
- lots of specific correlations! see e.g. [Barbieri et al 2011, Straub 2013]

Observables to watch: $S_{\phi K}$, $S_{\psi\phi}$, $|V_{ub}|$, $b \to s(d)\ell\bar{\ell}, \nu\bar{\nu}$, ...

$U(2)^3$ ideal for natural theories!

- SUSY with light stops (would also suppress EDMs)
- easy to satisfy collider and precision constraints
  e.g. in Composite Higgs models, see [Barbieri et al 2012]

Back up

Up sector within $U(2)^3$

Minimal $U(2)^3$: prediction of no detectable effects in

- Top FCNC [$\mathrm{BR}(t \to c\gamma, cZ)$]: below future LHC sensitivity
- CPV in $D - \bar{D}$ mixing [ϕ_{12}]: below future LHCb sensitivity
- Direct CPV in D decay [$A^D_{CP}(\pi\pi, KK)$]: below per mille level

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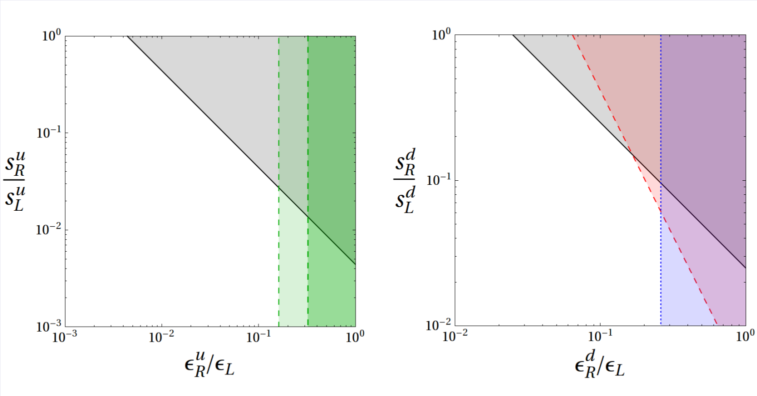
Generic $U(2)^3$ $\big[$add $V_u \sim (1,2,1)$, $V_d \sim (1,1,2)\big]$

- could explain ΔA^{exp}_{CP}
- respecting all current flavour and EDMs bounds
- keeping the same null predictions for $\mathrm{BR}(t \to c\gamma, cZ)$ and ϕ_{12}

Generic $U(2)^3$: bounds and new effects

$$\Delta Y_{u,d} = L(s_L^{u,d}) \cdot \Delta Y_{u,d}^{\text{diag}} \cdot R(s_R^{u,d}), \quad V = (0, \epsilon_L), \quad V_{u,d} = (0, \epsilon_R^{u,d})$$

$s_L^{u,d}$, ϵ_L fixed from tree level observables, $s_R^{u,d}$, $\epsilon_R^{u,d}$ bounded from above



$\Lambda = 3\,\mathrm{TeV}$ and $c_i \sin\phi_i = 1$ ($\rightarrow$ constraints are maximized)

Legend: black $= d_n$, green $= \Delta A_{CP}^D$, red $= \epsilon_K$, blue $= \epsilon'_K$