LEPTOQUARKS

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Malá Skála, 9 Apr 2018

Outline

1. LeptoQuarks in context of minimal SM extensions

2. Phenomenology of LQs in meson physics

3. LQs in $SU(4) \times SU(2)_L \times U(1)_R$ model

LeptoQuarks in the context of minimal SM extensions

- Recall: Standard Model

Gauge group:

$$SU(3)_c \otimes SU(2)_L \otimes U(1)_Y \longrightarrow SU(3)_c \otimes U(1)_Q$$

3 generations of fermions:

$$L^i = \begin{pmatrix} \nu_L \\ e_L \end{pmatrix} \qquad e_R \qquad Q^{\alpha i} = \begin{pmatrix} u_L^\alpha \\ d_L^\alpha \end{pmatrix} \qquad u_R^\alpha \qquad d_R^\alpha$$

$$Y = -\frac{1}{2} \qquad Y = -1 \qquad Y = +\frac{1}{6} \qquad Y = +\frac{2}{3} \qquad Y = -\frac{1}{3}$$

Scalar field:

$$H^i = \begin{pmatrix} \phi^+ \\ \phi^0 \end{pmatrix} \qquad Y = +\frac{1}{2}$$

LeptoQuarks in the context of minimal SM extensions

- Recall: Standard Model

$$\begin{aligned}\mathcal{L}_{SM} = \quad & -\tfrac{1}{4}B_{\mu\nu}B^{\mu\nu} - \tfrac{1}{2}A^{i}_{j\mu\nu}A^{j\mu\nu}_{i} - \tfrac{1}{2}G^{\alpha}_{\mu\nu\beta}G^{\beta\mu\nu}_{\alpha} \\ & +\overline{L}_i i\not{D}^{i}_{j}L^{j} + \overline{e}i\not{D}e + \overline{Q}_{i\alpha}i\not{D}^{i\alpha}_{j\beta}Q^{j\beta} + \overline{u}_{\alpha}i\not{D}^{\alpha}_{\beta}u^{\beta} + \overline{d}_{\alpha}i\not{D}^{\alpha}_{\beta}d^{\beta} \\ & + (D_{\mu}H)^{\dagger}_{k}D^{k\mu}_{j}H^{j} + \mu^2 H^{\dagger}_{i}H^{i} - \lambda\left(H^{\dagger}_{i}H^{i}\right)^2 \\ & + \left(\overline{Q}_{i\alpha}y_{(d)}d^{\alpha}\varepsilon^{ij}H^{\dagger}_{j} + \overline{Q}_{i\alpha}y_{(u)}u^{\alpha}H^{i} + \overline{L}_{i}y_{(e)}e\,H^{i}\right) + \text{h.c.}\end{aligned}$$

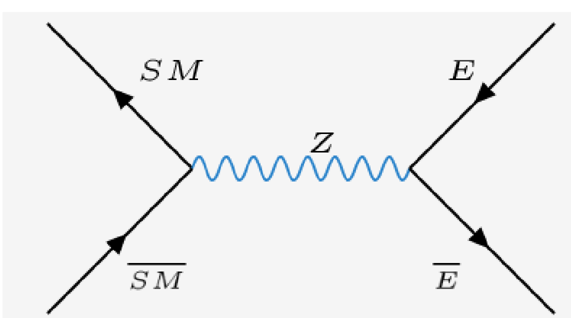
Simple extensions of SM

What could be the next elementary particle discovered on colliders?

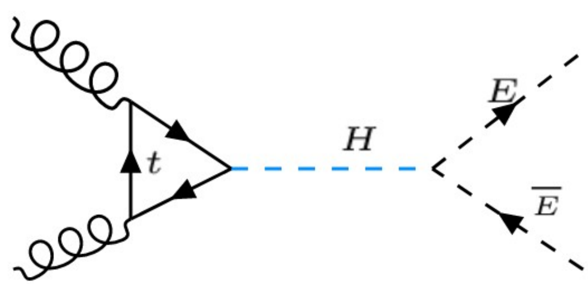
Fermions

Bosons

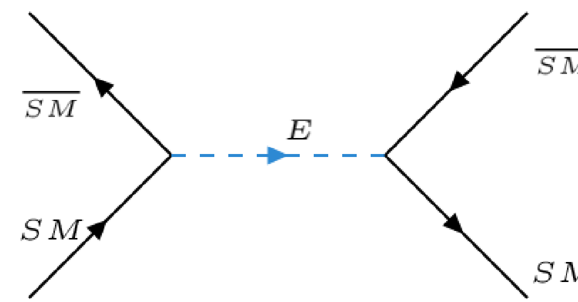
Matter



Extended Higgs sector



Mediators



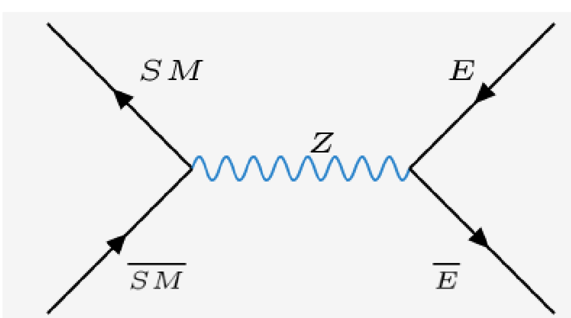
- *enormous number of possibilities*
- *limited number of possibilities*

Simple extensions of SM

What could be the next elementary particle discovered on colliders?

Fermions

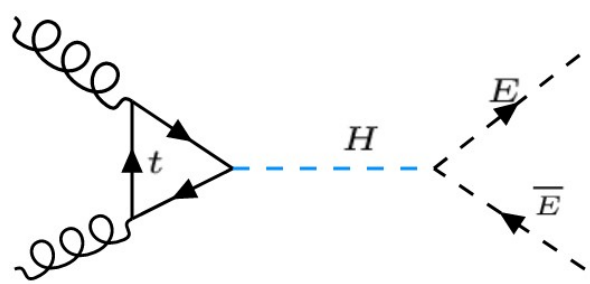
Matter



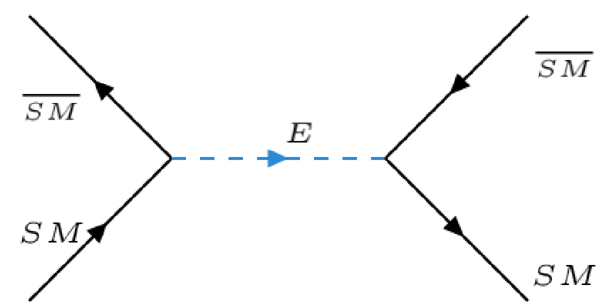
- *enormous number of possibilities*

Bosons

Extended Higgs sector



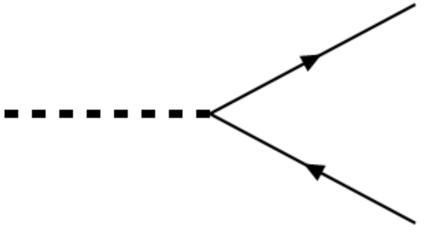
Mediators



- *limited number of possibilities*

Yukawa interacion

- Lorentz invariance:



$$\overline{\psi_R^{(1)}}\psi_L^{(2)}\Phi + h.c.$$

...known from SM

$$\psi_L^{(1)\,T}\mathcal{C}\,\psi_L^{(2)}\Phi + h.c.$$

$$\psi_R^{(1)\,T}\mathcal{C}\,\psi_R^{(2)}\Phi + h.c.$$

- Gauge invariance:

$$G_{\rm SM} = SU(3)_{\rm c} \otimes SU(2)_{\rm L} \otimes U(1)_{\rm Y}$$

contract all SU(3) and SU(2) indices

$$\sum_i Y^{(i)} = 0$$

Catalogue of possible scalar mediators

$\Psi\,(Y)^{3B}_{L}$ \ $\Psi\,(Y)^{3B}_{L}$	$\overline{\nu_R}\,(0)^{0}_{-1}$	$\overline{e_R}\,(-1)^{0}_{-1}$	$L^j\,(-\frac{1}{2})^{0}_{1}$	$\overline{d_{R\beta}}\,(\frac{1}{3})^{-1}_{0}$	$\overline{u_{R\beta}}\,(-\frac{2}{3})^{-1}_{0}$	$Q^{j\beta}\,(\frac{1}{6})^{1}_{0}$
$Q^{i\alpha}=\begin{pmatrix}u_L\\ d_L\end{pmatrix}^{\alpha}\,(\frac{1}{6})^{1}_{0}$						
$\overline{u_{R\alpha}}\,(-\frac{2}{3})^{-1}_{0}$						
$\overline{d_{R\alpha}}\,(\frac{1}{3})^{-1}_{0}$						
$L^{i}=\begin{pmatrix}\nu_L\\ e_L\end{pmatrix}\,(-\frac{1}{2})^{0}_{1}$						
$\overline{e_R}\,(-1)^{0}_{-1}$						
$\overline{\nu_R}\,(0)^{0}_{-1}$						

$i, j \in \{1,2\} \ldots SU(2)_L$
$\alpha, \beta, \gamma \in \{1,2,3\} \ldots SU(3)_C$
Multiple indices of same kind are symmetric

Catalogue of possible scalar mediators

$\Psi\,(Y)^{3B}_L$ (columns) / $\Psi\,(Y)^{3B}_L$ (rows)	$\overline{\nu_R}\,(0)^{0}_{-1}$	$\overline{e_R}\,(-1)^{0}_{-1}$	$L^j\,(-\frac{1}{2})^{0}_{1}$	$\overline{d_{R\beta}}\,(\frac{1}{3})^{-1}_{0}$	$\overline{u_{R\beta}}\,(-\frac{2}{3})^{-1}_{0}$	$Q^{j\beta}\,(\frac{1}{6})^{1}_{0}$
$Q^{i\alpha}=\begin{pmatrix}u_L\\ d_L\end{pmatrix}^{\alpha}\,(\frac{1}{6})^{1}_{0}$	$\Phi^{\dagger}_{\alpha i}\,(-\frac{1}{6})$	$\Phi^{\dagger}_{\alpha i}\,(-\frac{7}{6})$	$\chi^{\dagger}_{\alpha}\varepsilon_{ij}$ $X^{\dagger}_{\alpha(ij)}$ $(\frac{1}{3})$	$H^{\dagger}_{i}\delta^{\beta}_{\alpha}$ $\Phi^{\dagger\beta}_{j\alpha}$ $(-\frac{1}{2})$	$H^{j}\varepsilon_{ij}\delta^{\beta}_{\alpha}$ $X^{j\beta}_{\alpha}\varepsilon_{ij}$ $(\frac{1}{2})$	$\chi^{\gamma}\,\varepsilon_{\alpha\beta\gamma}\,\varepsilon_{ij}$ $\chi_{\alpha\beta}\,\varepsilon_{ij}$ $X^{\gamma}_{ij}\,\varepsilon_{\alpha\beta\gamma}$ $X_{\alpha\beta ij}$ $(-\frac{1}{3})$
$\overline{u_{R\alpha}}\,(-\frac{2}{3})^{-1}_{0}$	$\chi^{\alpha}\,(\frac{2}{3})$	$\chi^{\alpha}\,(-\frac{1}{3})$	$\Phi^{\alpha i}\,\varepsilon_{ij}\,(\frac{7}{6})$	$\chi^{\dagger}_{\gamma}\,\varepsilon^{\alpha\beta\gamma}$ $\chi^{\dagger\alpha\beta}$ $(\frac{1}{3})$	$\chi^{\dagger}_{\gamma}\,\varepsilon^{\alpha\beta\gamma}$ $\chi^{\dagger\alpha\beta}$ $(\frac{4}{3})$	
$\overline{d_{R\alpha}}\,(\frac{1}{3})^{-1}_{0}$	$\chi^{\alpha}\,(-\frac{1}{3})$	$\chi^{\alpha}\,(-\frac{4}{3})$	$\Phi^{\alpha i}\,\varepsilon_{ij}\,(\frac{1}{6})$	$\chi^{\dagger}_{\gamma}\,\varepsilon^{\alpha\beta\gamma}$ $\chi^{\dagger\alpha\beta}$ $(-\frac{2}{3})$		
$L^{i}=\begin{pmatrix}\nu_L\\ e_L\end{pmatrix}\,(-\frac{1}{2})^{0}_{1}$	$H^{j}\,\varepsilon_{ij}\,(\frac{1}{2})$	$H^{\dagger}_{i}\,(-\frac{1}{2})$	$\varphi\,\varepsilon_{ij}$ Δ_{ij} (1)			
$\overline{e_R}\,(-1)^{0}_{-1}$	$\varphi^{\dagger}\,(-1)$	$\varphi^{\dagger}\,(-2)$				
$\overline{\nu_R}\,(0)^{0}_{-1}$	$\varphi\,(0)$					

$i, j \in \{1,2\} \ldots SU(2)_L$
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Catalogue of possible scalar mediators

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$Q^{i\alpha}=\begin{pmatrix} u_L \\ d_L \end{pmatrix}^{\alpha}\,(\frac{1}{6})^1_0$	$\Phi^{\dagger}_{\alpha i}\,(-\frac{1}{6})$	$\Phi^{\dagger}_{\alpha i}\,(-\frac{7}{6})$	$\chi^{\dagger}_{\alpha}\,\varepsilon_{ij}$, $X^{\dagger}_{\alpha(ij)}$ $(\frac{1}{3})$	$H^{\dagger}_i\,\delta^{\beta}_{\alpha}$, $\Phi^{\dagger\beta}_{j\alpha}$ $(-\frac{1}{2})$	$H^j\,\varepsilon_{ij}\,\delta^{\beta}_{\alpha}$, $X^{j\beta}_{\alpha}\,\varepsilon_{ij}$ $(\frac{1}{2})$	$\chi^{\gamma}\,\varepsilon_{\alpha\beta\gamma}\,\varepsilon_{ij}$, $\chi_{\alpha\beta}\,\varepsilon_{ij}$, $X^{\gamma}_{ij}\,\varepsilon_{\alpha\beta\gamma}$, $X_{\alpha\beta ij}$ $(-\frac{1}{3})$
$\overline{u_{R\alpha}}\,(-\frac{2}{3})^{-1}_0$	$\chi^{\alpha}\,(\frac{2}{3})$	$\chi^{\alpha}\,(-\frac{1}{3})$	$\Phi^{\alpha i}\,\varepsilon_{ij}\,(\frac{7}{6})$	$\chi^{\dagger}_{\gamma}\,\varepsilon^{\alpha\beta\gamma}$, $\chi^{\dagger\alpha\beta}$ $(\frac{1}{3})$	$\chi^{\dagger}_{\gamma}\,\varepsilon^{\alpha\beta}$ [illegible]	
$\overline{d_{R\alpha}}\,(\frac{1}{3})^{-1}_0$	$\chi^{\alpha}\,(-\frac{1}{3})$	$\chi^{\alpha}\,(-\frac{4}{3})$	$\Phi^{\alpha i}\,\varepsilon_{ij}\,(\frac{1}{6})$	$\chi^{\dagger}_{\gamma}\,\varepsilon^{\alpha\beta\gamma}$, $\chi^{\dagger\alpha\beta}$ $(-\frac{2}{3})$		
$L^i=\begin{pmatrix} \nu_L \\ e_L \end{pmatrix}\,(-\frac{1}{2})^0_1$	$H^j\,\varepsilon_{ij}\,(\frac{1}{2})$	$H^{\dagger}_i\,(-\frac{1}{2})$	$\varphi\,\varepsilon_{ij}$, Δ_{ij} (1)			
$\overline{e_R}\,(-1)^0_{-1}$	$\varphi^{\dagger}\,(-1)$	$\varphi^{\dagger}$ [illegible]				
$\overline{\nu_R}\,(0)^0_{-1}$	$\varphi\,(0)$					

LEPTOQUARKS

DIQUARKS

DILEPTONS

Baryon & Lepton numbers

$\Psi(Y)^{3B}_L$ \ $\Psi(Y)^{3B}_L$	$\overline{\nu_R}\,(0)^0_{-1}$	$\overline{e_R}\,(-1)^0_{-1}$	$L^j\,(-\frac{1}{2})^0_1$	$\overline{d_{R\beta}}\,(\frac{1}{3})^{-1}_0$	$\overline{u_{R\beta}}\,(-\frac{2}{3})^{-1}_0$	$Q^{j\beta}\,(\frac{1}{6})^1_0$
$Q^{i\alpha}=\begin{pmatrix}u_L\\d_L\end{pmatrix}^\alpha\,(\frac{1}{6})^1_0$	$\Phi^\dagger_{\alpha i}\,(-\frac{1}{6})$	$\Phi^\dagger_{\alpha i}\,(-\frac{7}{6})$	$\chi^\dagger_\alpha\,\varepsilon_{ij}$, $X^\dagger_{\alpha(ij)}$ $(\frac{1}{3})$	$H^\dagger_i\,\delta^\beta_\alpha$, $\Phi^{\dagger\beta}_{j\alpha}$ $(-\frac{1}{2})$	$H^j\,\varepsilon_{ij}\,\delta^\beta_\alpha$, $X^{j\beta}_\alpha\,\varepsilon_{ij}$ $(\frac{1}{2})$	$\chi^\gamma\,\varepsilon_{\alpha\beta\gamma}\,\varepsilon_{ij}$, $\chi_{\alpha\beta}\,\varepsilon_{ij}$, $X^\gamma_{ij}\,\varepsilon_{\alpha\beta\gamma}$, $X_{\alpha\beta ij}$ $(-\frac{1}{3})$
$\overline{u_{R\alpha}}\,(-\frac{2}{3})^{-1}_0$	χ^α	$\chi^\alpha\,(-\frac{1}{3})$	$\Phi^{\alpha i}\,\varepsilon_{ij}\,(\frac{7}{6})$	$\chi^\dagger_\gamma\,\varepsilon^{\alpha\beta\gamma}$, $\chi^{\dagger\alpha\beta}$ $(\frac{1}{3})$	$\chi^\dagger_\gamma\,\varepsilon^{\alpha\beta}$	
$\overline{d_{R\alpha}}\,(\frac{1}{3})^{-1}_0$	$\chi^\alpha\,(-\frac{1}{3})$	$\chi^\alpha\,(-\frac{4}{3})$	$\Phi^{\alpha i}\,\varepsilon_{ij}\,(\frac{1}{6})$	$\chi^\dagger_\gamma\,\varepsilon^{\alpha\beta\gamma}$, $\chi^{\dagger\alpha\beta}$		
$L^i=\begin{pmatrix}\nu_L\\e_L\end{pmatrix}\,(-\frac{1}{2})^0_1$	$H^j\,\varepsilon_{ij}\,(\frac{1}{2})$	$H^\dagger_i\,(-\frac{1}{2})$	$\varphi\,\varepsilon_{ij}$, Δ_{ij} (1)			
$\overline{e_R}\,(-1)^0_{-1}$	$\varphi^\dagger\,(-1)$					
$\overline{\nu_R}\,(0)^0_{-1}$	$\varphi\,(0)$					

3B = 1, L = ±1

3B = 2, L=0

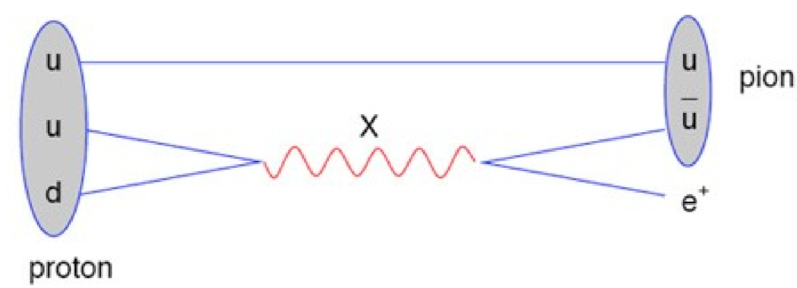
B = 0, L = 2

Existence of LQs does not necessarily imply Baryon / Lepton number violation!

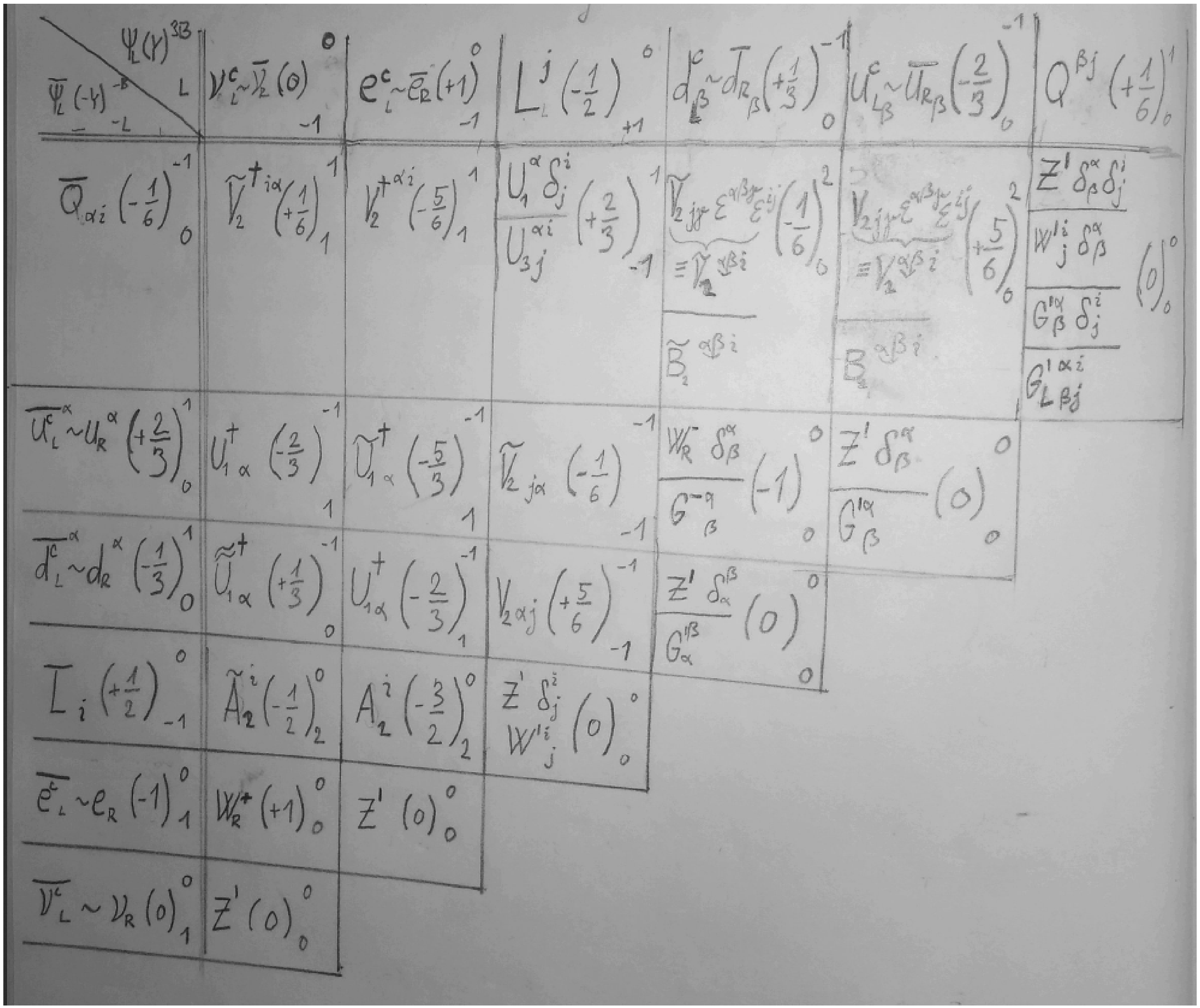
However, ...

Baryon & Lepton numbers

$\Psi\,(Y)^{3B}_{L}$ \ $\Psi\,(Y)^{3B}_{L}$	$\overline{\nu_R}\,(0)^{0}_{-1}$	$\overline{e_R}\,(-1)^{0}_{-1}$	$L^j\,(-\frac{1}{2})^{0}_{1}$	$\overline{d}_{R\beta}\,(\frac{1}{3})^{-1}_{0}$	$\overline{u}_{R\beta}\,(-\frac{2}{3})^{-1}_{0}$	$Q^{j\beta}\,(\frac{1}{6})^{1}_{0}$
$Q^{i\alpha}=\begin{pmatrix}u_L\\ d_L\end{pmatrix}^{\alpha}\,(\frac{1}{6})^{1}_{0}$	$\Phi^{\dagger}_{\alpha i}\,(-\frac{1}{6})$	$\Phi^{\dagger}_{\alpha i}\,(-\frac{7}{6})$	$\chi^{\dagger}_{\alpha}\varepsilon_{ij}$, $X^{\dagger}_{\alpha(ij)}$ $(\frac{1}{3})$	$H^{\dagger}_{i}\delta^{\beta}_{\alpha}$, $\Phi^{\dagger\beta}_{j\alpha}$ $(-\frac{1}{2})$	$H^{j}\varepsilon_{ij}\delta^{\beta}_{\alpha}$, $X^{j\beta}_{\alpha}\varepsilon_{ij}$ $(\frac{1}{2})$	$\chi^{\gamma}\varepsilon_{\alpha\beta\gamma}\varepsilon_{ij}$, $\chi_{\alpha\beta}\varepsilon_{ij}$, $X^{\gamma}_{ij}\varepsilon_{\alpha\beta\gamma}$, $X_{\alpha\beta ij}$ $(-\frac{1}{3})$
$\overline{u}_{R\alpha}\,(-\frac{2}{3})^{-1}_{0}$	$\chi^{\alpha}\,(\frac{2}{3})$	$\chi^{\alpha}\,(-\frac{1}{3})$	$\Phi^{\alpha i}\varepsilon_{ij}\,(\frac{7}{6})$	$\chi^{\dagger}_{\gamma}\varepsilon^{\alpha\beta\gamma}$, $\chi^{\dagger\alpha\beta}$ $(\frac{1}{3})$	$\chi^{\dagger}_{\gamma}\varepsilon^{\alpha\beta\gamma}$, $\chi^{\dagger\alpha\beta}$ $(\frac{4}{3})$	
$\overline{d}_{R\alpha}\,(\frac{1}{3})^{-1}_{0}$	$\chi^{\alpha}\,(-\frac{1}{3})$	$\chi^{\alpha}\,(-\frac{4}{3})$	$\Phi^{\alpha i}\varepsilon_{ij}\,(\frac{1}{6})$	$\chi^{\dagger}_{\gamma}\varepsilon^{\alpha\beta\gamma}$, $\chi^{\dagger\alpha\beta}$ $(\frac{2}{3})$		
$L^{i}=\begin{pmatrix}\nu_L\\ e_L\end{pmatrix}\,(-\frac{1}{2})^{0}_{1}$	$H^{j}\varepsilon_{ij}\,(\frac{1}{2})$	$H^{\dagger}_{i}\,(-\frac{1}{2})$	$\varphi\,\varepsilon_{ij}$, Δ_{ij} (1)			
$\overline{e_R}\,(-1)^{0}_{-1}$	$\varphi^{\dagger}\,(-1)$	$\varphi^{\dagger}\,(-2)$				
$\overline{\nu_R}\,(0)^{0}_{-1}$	$\varphi\,(0)$					



Catalogue of possible vector mediators



Complete list of leptoquarks

$(SU(3), SU(2), U(1))$	Spin	Symbol	Type	F
$(\overline{\mathbf{3}}, \mathbf{3}, 1/3)$	0	S_3	$LL\,(S_1^L)$	-2
$(\mathbf{3}, \mathbf{2}, 7/6)$	0	R_2	$RL\,(S_{1/2}^L),\ LR\,(S_{1/2}^R)$	0
$(\mathbf{3}, \mathbf{2}, 1/6)$	0	$\tilde{R}_2$	$RL\,(\tilde{S}_{1/2}^L),\ \overline{LR}\,(\tilde{S}_{1/2}^{\overline{L}})$	0
$(\overline{\mathbf{3}}, \mathbf{1}, 4/3)$	0	$\tilde{S}_1$	$RR\,(\tilde{S}_0^R)$	-2
$(\overline{\mathbf{3}}, \mathbf{1}, 1/3)$	0	S_1	$LL\,(S_0^L),\ RR\,(S_0^R),\ \overline{RR}\,(S_0^{\overline{R}})$	-2
$(\overline{\mathbf{3}}, \mathbf{1}, -2/3)$	0	$\bar{S}_1$	$\overline{RR}\,(\bar{S}_0^{\overline{R}})$	-2
$(\mathbf{3}, \mathbf{3}, 2/3)$	1	U_3	$LL\,(V_1^L)$	0
$(\overline{\mathbf{3}}, \mathbf{2}, 5/6)$	1	V_2	$RL\,(V_{1/2}^L),\ LR\,(V_{1/2}^R)$	-2
$(\overline{\mathbf{3}}, \mathbf{2}, -1/6)$	1	$\tilde{V}_2$	$RL\,(\tilde{V}_{1/2}^L),\ \overline{LR}\,(\tilde{V}_{1/2}^{\overline{R}})$	-2
$(\mathbf{3}, \mathbf{1}, 5/3)$	1	$\tilde{U}_1$	$RR\,(\tilde{V}_0^R)$	0
$(\mathbf{3}, \mathbf{1}, 2/3)$	1	U_1	$LL\,(V_0^L),\ RR\,(V_0^R),\ \overline{RR}\,(V_0^{\overline{R}})$	0
$(\mathbf{3}, \mathbf{1}, -1/3)$	1	$\bar{U}_1$	$\overline{RR}\,(\bar{V}_0^{\overline{R}})$	0

1603.04993

LQs in flavour physics

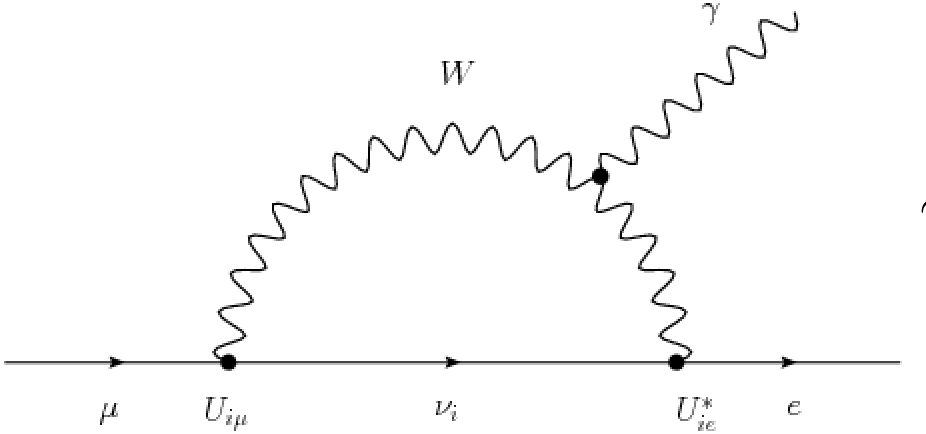
- Semileptonic meson decays

LQs necessarily imply at least one of:

- Lepton flavour violation (LFV)
- Lepton flavour universality violation (LFUV)

Lepton flavour violation (LFV)

- Experiment: $\mathrm{Br}\left(\mu \to e\gamma\right) < 4.2 \cdot 10^{-13}$
- Standard Model:
  - exact accidental symmetry $U(1)_e \otimes U(1)_\mu \otimes U(1)_\tau$
- SM + massive neutrinos:
  - LFV via neutrino oscillations
  - no measurable effect on collider physics

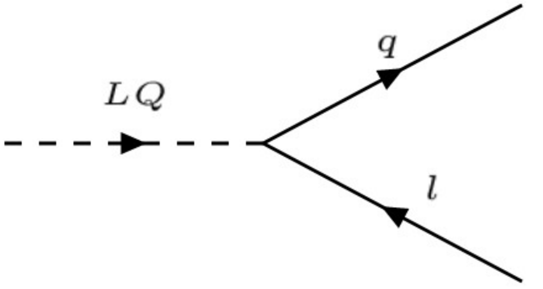


$\sim \frac{m_\nu}{m_W}$

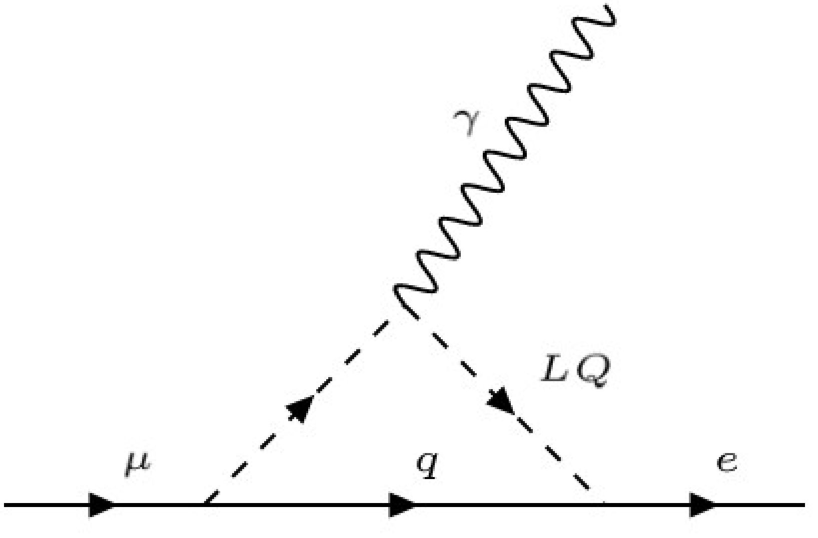
arXiv:1410.2099 [hep-ph]

Lepton flavour violation (LFV)

- LeptoQuarks:



$$Y_{\mathrm{LQ}}^{1/3} = \begin{pmatrix} y_{eu} & y_{ec} & y_{et} \\ y_{\mu u} & y_{\mu c} & y_{\mu t} \\ y_{\tau u} & y_{\tau c} & y_{\tau c} \end{pmatrix} \qquad Y_{\mathrm{LQ}}^{4/3} = \begin{pmatrix} y_{ed} & y_{es} & y_{eb} \\ y_{\mu d} & y_{\mu s} & y_{\mu b} \\ y_{\tau d} & y_{\tau s} & y_{\tau b} \end{pmatrix}$$



Experiment requires Y_{LQ} being “sparse”, e.g.

$$Y_{\mathrm{LQ}} = \begin{pmatrix} 0 & 0 & 0 \\ 0 & y_1 & y_2 \\ 0 & 0 & 0 \end{pmatrix}$$

Lepton Flavour Universality Violation

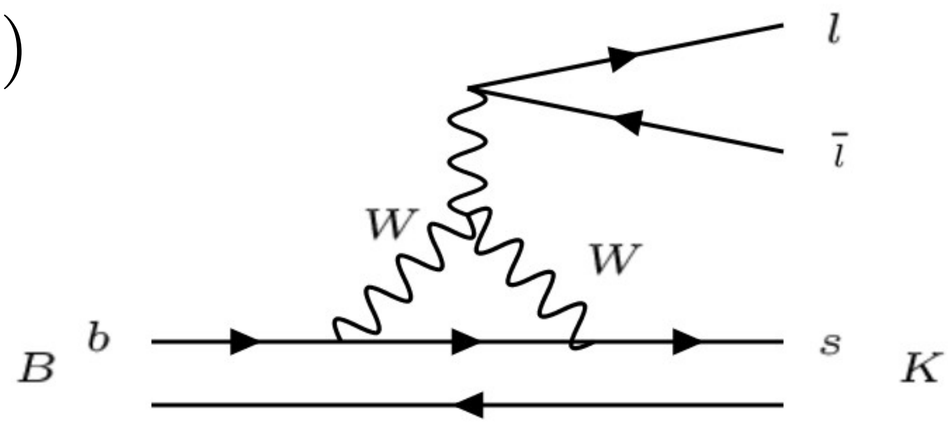
- Flavour universality = $U(3)_{e\mu\tau}$ symmetry
  - all 3 leptons have the same properties
  - e.g. $\sigma(p\,p \to X\,e^+\,e^-) = \sigma(p\,p \to X\,\mu^+\,\mu^-)$

- SM: explicitly violated by Higgs interactions
  - leptons have different masses
  - neglectable at HiE

B-physics anomalies

$$R(K) \equiv \frac{\mathrm{Br}\left(B \to K\mu^+\mu^-\right)}{\mathrm{Br}\left(B \to K e^+ e^-\right)}$$ (FCNC)

- Flavour–universal universe: $R(K) = 1$
- SM: $R(K) = 1 \pm O(10^{-4})$



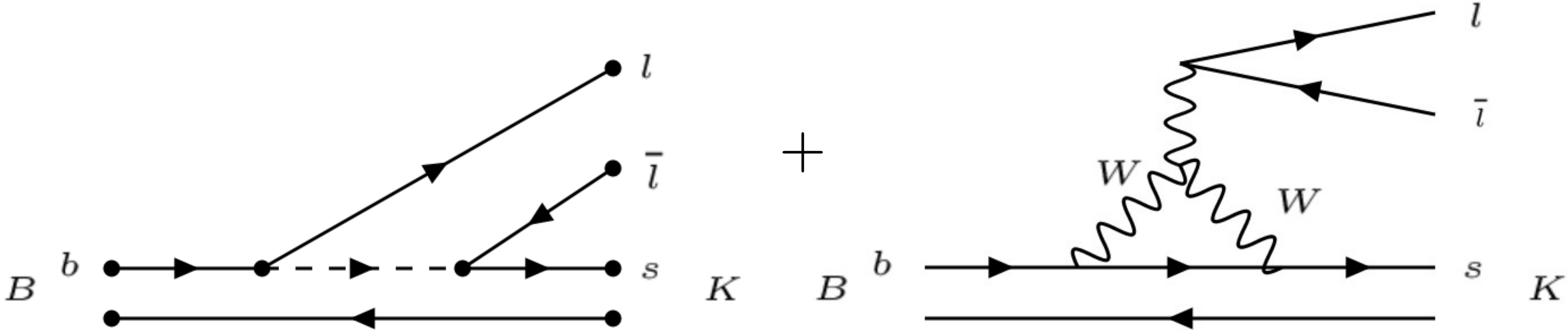
- Experiments in our universe (LHCb): 2.6σ dev.

$$R_K = 0.745^{+0.090}_{-0.074}\,(\mathrm{stat}) \pm 0.036\,(\mathrm{syst})$$ *1406.6482*

B-physics anomalies

$$R(K) \equiv \frac{(B \to K\mu^+\mu^-)}{(B \to Ke^+e^-)}$$ (FCNC)

- Leptoquarks:



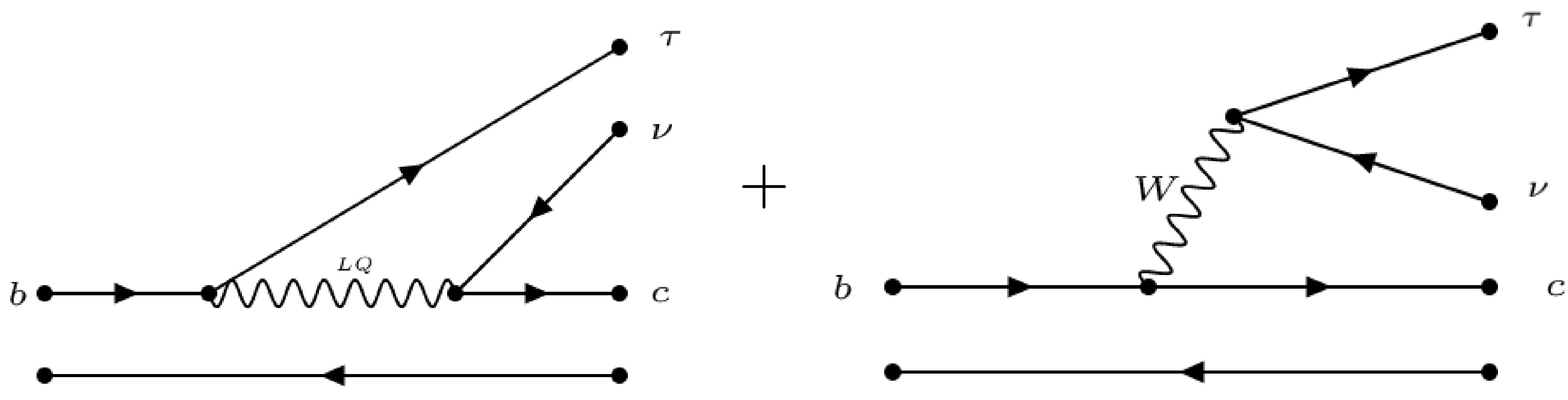
- Experiments in our universe (LHCb):

$$R_K = 0.745^{+0.090}_{-0.074}\,(\text{stat}) \pm 0.036\,(\text{syst})$$ *1406.6482*

B-physics anomalies

$$R(D^{(*)}) = \frac{\mathrm{Br}(B \to D^{(*)}\,\tau\,\nu)}{\mathrm{Br}(B \to D^{(*)}\,l\,\nu)}, \quad l = \mu, e$$

- FUU: $R(D) = R(D^*) = 1/2$
- SM: $R(D) = 0.300 \pm 0.010, \qquad R(D^*) = 0.252 \pm 0.05$
- Experiment: 4 σ deviation (BaBar, Belle, LHCb)

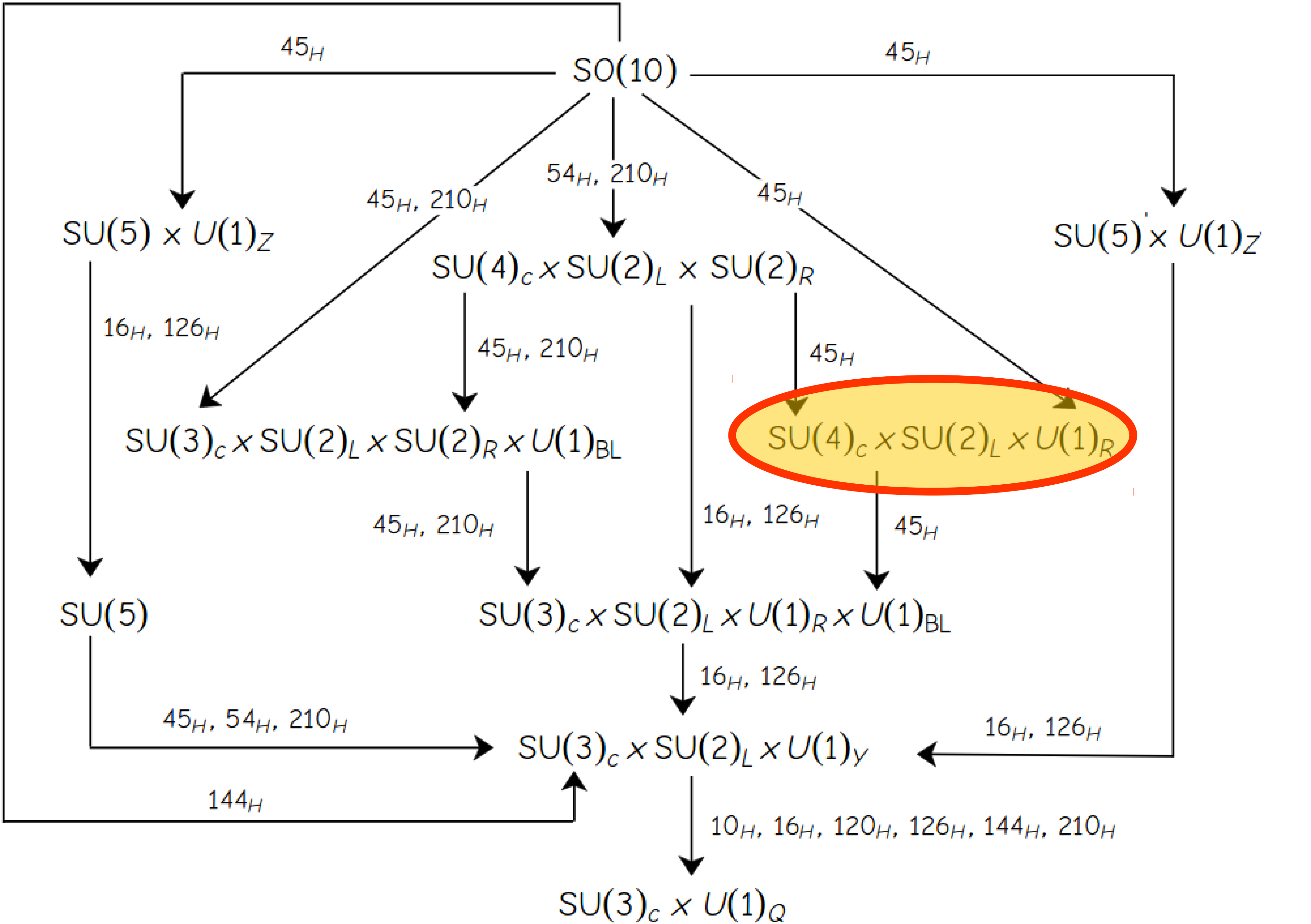


Other SM precission tests

- Muon anomalous magnetic moment
- Hundreds of other observables without significant deviation
  - Higgs sector
  - purely hadronic processes

$SU(4) \times SU(2)_L \times U(1)_R$

- Lepton number as the fourth color
- Contains both vector and scalar TeVish LQs
- Conserves Baryon number
- Goal: model explaining R(K) & R(D) but fullfilling all other SM-precission constraints
- Issue: Unitarity of the gauge coupling matrix



borrowed from Kateřina Jarkovská

Summary

- LeptoQuarks are (so far) hypothetical particles
- Observed discrepancies in (only) semileptonic meson decays points towards their existence
- We are working on an SU(4)-based model which is supposed to be compatible with all SM-precission data
- Direct searches for TeV LQs are thus very well motivated