From the EFT to the UV and back: the SMEFT one-loop dictionary

Based on 2303.16965, 2412.XXX

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Travelling through the SMEFT

Data points to IR pattern

Which UV models?

Which low-energy pheno?

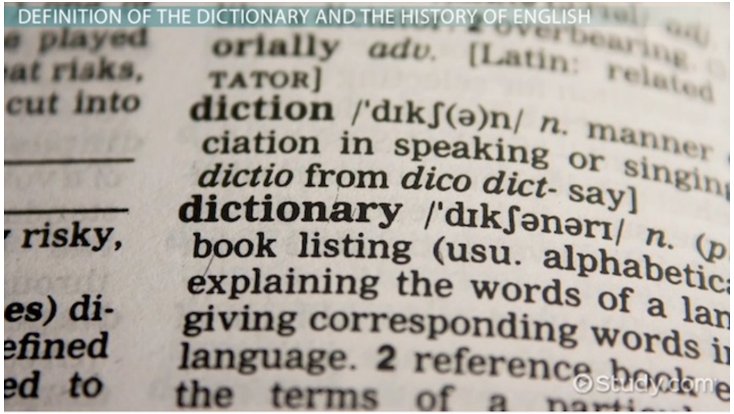
↓

From the EFT

To the UV

And back

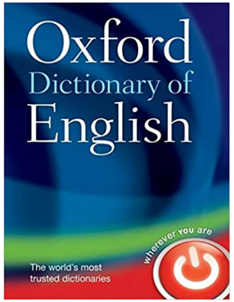
What are UV/IR dictionaries



$$\mathcal{L}_{\rm UV}$$

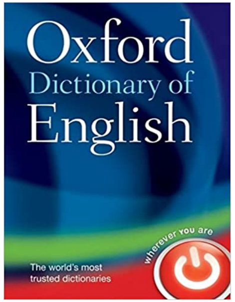
$$\Updownarrow$$

IR data



Bottom-up approach: UV/IR dictionaries

$$\mathcal{L}_{\text{UV}}$$



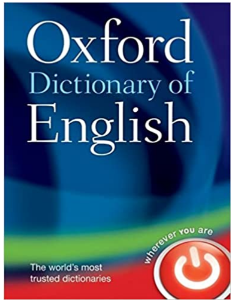
$$\mathcal{L}_{\text{SMEFT}} = \mathcal{L}_{\text{SM}} + \frac{\mathcal{L}_6}{\Lambda^2}$$

- What is the data telling us?
- UV/IR dictionaries tell us ***all*** SM extensions which can contribute to a particular experimental observable (at a given order in the EFT expansion)

Top-down approach: UV/IR dictionaries

$$\mathcal{L}_{\text{UV}}$$

$$\downarrow$$

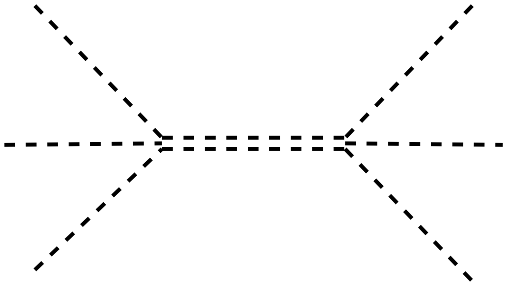


$$\mathcal{L}_{\text{SMEFT}} = \mathcal{L}_{\text{SM}} + \frac{\mathcal{L}_6}{\Lambda^2}$$

- What are the low-energy consequences of a particular UV scenario?
- UV/IR dictionaries allows to map all these contributions finding correlations among WCs.
  - Done at a specific perturbative order through matching.

Dictionary at tree-level

- Tree-level dictionary to the SMEFT @ dim-6 already exists, with ***all*** possible extensions which can generate WCs and their explicity contribution.



$\mathcal{S}$	$\mathcal{S}_1$	$\mathcal{S}_2$	φ	Ξ	Ξ_1	Θ_1	Θ_3
$(1,1)_0$	$(1,1)_1$	$(1,1)_2$	$(1,2)_{\frac{1}{2}}$	$(1,3)_0$	$(1,3)_1$	$(1,4)_{\frac{1}{2}}$	$(1,4)_{\frac{3}{2}}$
ω_1	ω_2	ω_4	Π_1	Π_7	ζ		
$(3,1)_{-\frac{1}{3}}$	$(3,1)_{\frac{2}{3}}$	$(3,1)_{-\frac{4}{3}}$	$(3,2)_{\frac{1}{6}}$	$(3,2)_{\frac{7}{6}}$	$(3,3)_{-\frac{1}{3}}$		
Ω_1	Ω_2	Ω_4	Υ	Φ			
$(6,1)_{\frac{1}{3}}$	$(6,1)_{-\frac{2}{3}}$	$(6,1)_{\frac{4}{3}}$	$(6,3)_{\frac{1}{3}}$	$(8,2)_{\frac{1}{2}}$			

N	E	Δ_1	Δ_3	Σ	Σ_1	
$(1,1)_0$	$(1,1)_{-1}$	$(1,2)_{-\frac{1}{2}}$	$(1,2)_{-\frac{3}{2}}$	$(1,3)_0$	$(1,3)_{-1}$	
U	D	Q_1	Q_5	Q_7	T_1	T_2
$(3,1)_{\frac{2}{3}}$	$(3,1)_{-\frac{1}{3}}$	$(3,2)_{\frac{1}{6}}$	$(3,2)_{-\frac{5}{6}}$	$(3,2)_{\frac{7}{6}}$	$(3,3)_{-\frac{1}{3}}$	$(3,3)_{\frac{2}{3}}$

$\mathcal{B}$	$\mathcal{B}_1$	$\mathcal{W}$	$\mathcal{W}_1$	$\mathcal{G}$	$\mathcal{G}_1$	$\mathcal{H}$	$\mathcal{L}_1$
$(1,1)_0$	$(1,1)_1$	$(1,3)_0$	$(1,3)_1$	$(8,1)_0$	$(8,1)_1$	$(8,3)_0$	$(1,2)_{\frac{1}{2}}$
$\mathcal{L}_3$	$\mathcal{U}_2$	$\mathcal{U}_5$	$\mathcal{Q}_1$	$\mathcal{Q}_5$	$\mathcal{X}$	$\mathcal{Y}_1$	$\mathcal{Y}_5$
$(1,2)_{-\frac{3}{2}}$	$(3,1)_{\frac{2}{3}}$	$(3,1)_{\frac{5}{3}}$	$(3,2)_{\frac{1}{6}}$	$(3,2)_{-\frac{5}{6}}$	$(3,3)_{\frac{2}{3}}$	$(\bar{6},2)_{\frac{1}{6}}$	$(\bar{6},2)_{-\frac{5}{6}}$

De Blas, Criado, Perez-Victoria, Santiago, 1711.10391

Dictionary at tree-level

- Tree-level dictionary to the SMEFT @ dim-6 already exists, with ***all*** possible extensions which can generate WCs and their explicity contribution.
- Some operators can be generated at one-loop
  - Considering weakly coupled renormalizable UV

C. Arzt, M. B. Einhorn, and J. Wudka, hep-ph/9405214
Craig, Jiang, Li, Sutherland 2001.00017

$\mathcal{S}$	$\mathcal{S}_1$	$\mathcal{S}_2$	φ	Ξ	Ξ_1	Θ_1	Θ_3
$(1,1)_0$	$(1,1)_1$	$(1,1)_2$	$(1,2)_{\frac{1}{2}}$	$(1,3)_0$	$(1,3)_1$	$(1,4)_{\frac{1}{2}}$	$(1,4)_{\frac{3}{2}}$
ω_1	ω_2	ω_4	Π_1	Π_7	ζ		
$(3,1)_{-\frac{1}{3}}$	$(3,1)_{\frac{2}{3}}$	$(3,1)_{-\frac{4}{3}}$	$(3,2)_{\frac{1}{6}}$	$(3,2)_{\frac{7}{6}}$	$(3,3)_{-\frac{1}{3}}$		
Ω_1	Ω_2	Ω_4	Υ	Φ			
$(6,1)_{\frac{1}{3}}$	$(6,1)_{-\frac{2}{3}}$	$(6,1)_{\frac{4}{3}}$	$(6,3)_{\frac{1}{3}}$	$(8,2)_{\frac{1}{2}}$			

N	E	Δ_1	Δ_3	Σ	Σ_1	
$(1,1)_0$	$(1,1)_{-1}$	$(1,2)_{-\frac{1}{2}}$	$(1,2)_{-\frac{3}{2}}$	$(1,3)_0$	$(1,3)_{-1}$	
U	D	Q_1	Q_5	Q_7	T_1	T_2
$(3,1)_{\frac{2}{3}}$	$(3,1)_{-\frac{1}{3}}$	$(3,2)_{\frac{1}{6}}$	$(3,2)_{-\frac{5}{6}}$	$(3,2)_{\frac{7}{6}}$	$(3,3)_{-\frac{1}{3}}$	$(3,3)_{\frac{2}{3}}$

$\mathcal{B}$	$\mathcal{B}_1$	$\mathcal{W}$	$\mathcal{W}_1$	$\mathcal{G}$	$\mathcal{G}_1$	$\mathcal{H}$	$\mathcal{L}_1$
$(1,1)_0$	$(1,1)_1$	$(1,3)_0$	$(1,3)_1$	$(8,1)_0$	$(8,1)_1$	$(8,3)_0$	$(1,2)_{\frac{1}{2}}$
$\mathcal{L}_3$	$\mathcal{U}_2$	$\mathcal{U}_5$	$\mathcal{Q}_1$	$\mathcal{Q}_5$	$\mathcal{X}$	$\mathcal{Y}_1$	$\mathcal{Y}_5$
$(1,2)_{-\frac{3}{2}}$	$(3,1)_{\frac{2}{3}}$	$(3,1)_{\frac{5}{3}}$	$(3,2)_{\frac{1}{6}}$	$(3,2)_{-\frac{5}{6}}$	$(3,3)_{\frac{2}{3}}$	$(\bar{6},2)_{\frac{1}{6}}$	$(\bar{6},2)_{-\frac{5}{6}}$

De Blas, Criado, Perez-Victoria, Santiago, 1711.10391

Dictionary at one-loop

- Non-linear couplings to the SM – less constrained – contribute only at loop-level;
  - Dark Matter or exotically charged particles
- Significant progress in the past few years in the development of automatic tools to perform matching at one-loop.

matchmakereft

MATCHETE

Carmona, Lazopoulos, Olgoso, Santiago, 2112.10787

Fuentes-Martín, König, Pagès, Thomsen, Wilsch, 2212.04510

The dictionary

$$\begin{aligned}\mathcal{L}_{\mathrm{UV}} =&\delta_{\Psi_a}\bar{\Psi}_a\left[\mathrm{i}\not{D} - M_{\Psi_a}\right]\Psi_a + \delta_{\Phi_a}\left[|D_\mu\Phi_a|^2 - M^2_{\Phi_a}|\Phi_a|^2\right] \\ &+ \sum_{\chi=L,R}\left[Y^\chi_{abc}\overline{\Psi}_a P_\chi \Psi_b\Phi_c + \widetilde{Y}^\chi_{abc}\overline{\Psi}_a P_\chi\Psi_b\Phi^\dagger_c\right. \\ &\qquad\left. + X^\chi_{abc}\overline{\Psi^c}_a P_\chi\Psi_b\Phi_c + \widetilde{X}^\chi_{abc}\overline{\Psi^c}_a P_\chi\Psi_b\Phi^\dagger_c + \mathrm{h.c.}\right] \\ &+\left[\kappa_{abc}\Phi_a\Phi_b\Phi_c + \kappa'_{abc}\Phi_a\Phi_b\Phi^\dagger_c + \lambda_{abcd}\Phi_a\Phi_b\Phi_c\Phi_d\right. \\ &\left. + \ \lambda'_{abcd}\Phi_a\Phi_b\Phi_c\Phi^\dagger_d + \lambda''_{abcd}\Phi_a\Phi_b\Phi^\dagger_c\Phi^\dagger_d + \mathrm{h.c.}\right],\end{aligned}$$

Gauge structure of UV couplings kept arbitrary.
Match diagrammatically

The dictionary

WCs are therefore given in terms of UV couplings and Clebsch-Gordon tensors.

Example: G.G., Olgoso 2205.04480

$$\alpha_{e\gamma}^{2,2} = \frac{iN_c e}{4} y_M y_F y_b^R \sum_{IJ} T_{I2J} \left[\gamma_\Psi T_{I'I}^{\gamma,\Psi} T'_{2JI'} + \gamma_\Phi T_{JJ'}^{\gamma,\Phi} T'_{2IJ'} \right]$$

The next step is to specify **Quantum numbers of UV scenario** – **GroupMath** computes possible CGs

Fonseca 2011.01764

The dictionary

Dictionary can be used through the Mathematica package:
SOLD (SMEFT One-Loop Dictionary)

```
In[1]:= << SOLD`
SMEFT One Loop Dictionary loaded
Version: 1.0.1
Authors: Guilherme Guedes, Pablo Olgoso, José Santiago
Reference: arXiv:2303.16965
Webpage: https://gitlab.com/jsantiago_ugr/sold
XXXXXXXXXXXXXXXXXXXXXXXXXXX GroupMath XXXXXXXXXXXXXXXXXXXXXXXXXXX
Version: 1.1.2 (6/May/2020)
Author: Renato Fonseca
Reference: 2011.01764 [hep-th]
Website: renatofonseca.net/groupmath
Built-in documentation: here
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX-
   XXXX
```

Using the dictionary

Dictionary can be used in two directions:

Bottom-up: Which UV models generate a specific Wilson Coefficient?

```
ListModelsWarsaw[op,True]
```

No SM couplings (pointing to True)

```
In[224]:= ListModelsWarsaw[alphaOlq1, True]
```

Out[•]//MatrixForm=

Field Content	SU(3) ⊗ SU(2)	U(1)
$\{\phi 1\}$	$\{\phi 1 \to \mathbf{1} \otimes \mathbf{2}\}$	$\{Y_{\phi 1} \to -\frac{1}{2}\}$
$\{\phi 1\}$	$\{\phi 1 \to \mathbf{3} \otimes \mathbf{1}\}$	$\{Y_{\phi 1} \to -\frac{1}{3}\}$
$\{\phi 1\}$	$\{\phi 1 \to \mathbf{3} \otimes \mathbf{2}\}$	$\{Y_{\phi 1} \to \frac{7}{6}\}$
$\{\phi 1\}$	$\{\phi 1 \to \mathbf{3} \otimes \mathbf{3}\}$	$\{Y_{\phi 1} \to -\frac{1}{3}\}$

Using the dictionary

Dictionary can be used in two directions:

Bottom-up: Which UV models generate a specific Wilson Coefficient?

`ListModelsWarsaw[op,True]`

$\{\phi 1, \psi 1, \psi 2\}$	$\{\psi 1 \otimes \phi 1 \supset \mathbf{1} \otimes \mathbf{2},\ \psi 2 \otimes \phi 1 \supset \bar{\mathbf{3}} \otimes \mathbf{2}\}$	$\{Y_{\psi 1} \to -\frac{1}{2} - Y_{\phi 1},\ Y_{\psi 2} \to -\frac{1}{6} + Y_{\phi 1}\}$
$\{\phi 1, \psi 1, \psi 2\}$	$\{\psi 1 \otimes \phi 1 \supset \mathbf{1} \otimes \mathbf{2},\ \psi 2 \otimes \phi 1 \supset \bar{\mathbf{3}} \otimes \mathbf{2}\}$	$\{Y_{\psi 1} \to \frac{1}{2} + Y_{\phi 1},\ Y_{\psi 2} \to -\frac{1}{6} + Y_{\phi 1}\}$
$\{\phi 1, \psi 1, \psi 2\}$	$\{\psi 1 \otimes \phi 1 \supset \mathbf{1} \otimes \mathbf{2},\ \psi 2 \otimes \phi 1 \supset \mathbf{3} \otimes \mathbf{2}\}$	$\{Y_{\psi 1} \to -\frac{1}{2} - Y_{\phi 1},\ Y_{\psi 2} \to \frac{1}{6} - Y_{\phi 1}\}$
$\{\phi 1, \psi 1, \psi 2\}$	$\{\psi 1 \otimes \phi 1 \supset \mathbf{1} \otimes \mathbf{2},\ \psi 2 \otimes \phi 1 \supset \mathbf{3} \otimes \mathbf{2}\}$	$\{Y_{\psi 1} \to -\frac{1}{2} - Y_{\phi 1},\ Y_{\psi 2} \to \frac{1}{6} + Y_{\phi 1}\}$
$\{\phi 1, \psi 1, \psi 2\}$	$\{\psi 1 \otimes \phi 1 \supset \mathbf{1} \otimes \mathbf{2},\ \psi 2 \otimes \phi 1 \supset \mathbf{3} \otimes \mathbf{2}\}$	$\{Y_{\psi 1} \to \frac{1}{2} - Y_{\phi 1},\ Y_{\psi 2} \to \frac{1}{6} - Y_{\phi 1}\}$
$\{\phi 1, \psi 1, \psi 2\}$	$\{\psi 1 \otimes \phi 1 \supset \mathbf{1} \otimes \mathbf{2},\ \psi 2 \otimes \phi 1 \supset \mathbf{3} \otimes \mathbf{2}\}$	$\{Y_{\psi 1} \to -\frac{1}{2} + Y_{\phi 1},\ Y_{\psi 2} \to \frac{1}{6} - Y_{\phi 1}\}$

Using the dictionary

`ListValidQNs[restriction]`

```
In[13]:= modelQNs = ListValidQNs[listofmodels[[1, 145]]];
Print["Model restriction :", listofmodels[[1, 145]], "\nList of Models:\n",
 MatrixForm[Join[Take[modelQNs, {1, 3}], {{"....", "....", "...."}}, Take[modelQNs, {-3, -1}]]]]
```

Model restriction : $\left\{\{\phi 1, \psi 1, \psi 2\}, \{\psi 1 \otimes \overline{\phi 1} \supset \mathbf{3} \otimes \mathbf{2}, \psi 1 \otimes \psi 2 \supset \mathbf{1} \otimes \mathbf{2}, \psi 2 \otimes \phi 1 \supset \mathbf{3} \otimes \mathbf{1}\}, \left\{Y_{\psi 1} \to -\frac{1}{6} + Y_{\phi 1}, Y_{\psi 2} \to -\frac{1}{3} - Y_{\phi 1}\right\}\right\}$

List of Models:

$$\begin{pmatrix}
\phi 1 \to \mathbf{1} \otimes \mathbf{1} \otimes Y_{\phi 1} & \psi 1 \to \overline{\mathbf{3}} \otimes \mathbf{2} \otimes \left(-\frac{1}{6} + Y_{\phi 1}\right) & \psi 2 \to \mathbf{3} \otimes \mathbf{1} \otimes \left(-\frac{1}{3} - Y_{\phi 1}\right) \\
\phi 1 \to \mathbf{1} \otimes \mathbf{2} \otimes Y_{\phi 1} & \psi 1 \to \overline{\mathbf{3}} \otimes \mathbf{1} \otimes \left(-\frac{1}{6} + Y_{\phi 1}\right) & \psi 2 \to \mathbf{3} \otimes \mathbf{2} \otimes \left(-\frac{1}{3} - Y_{\phi 1}\right) \\
\phi 1 \to \mathbf{1} \otimes \mathbf{2} \otimes Y_{\phi 1} & \psi 1 \to \overline{\mathbf{3}} \otimes \mathbf{3} \otimes \left(-\frac{1}{6} + Y_{\phi 1}\right) & \psi 2 \to \mathbf{3} \otimes \mathbf{2} \otimes \left(-\frac{1}{3} - Y_{\phi 1}\right) \\
.... & .... & .... \\
\phi 1 \to \mathbf{15'} \otimes \mathbf{4} \otimes Y_{\phi 1} & \psi 1 \to \mathbf{10} \otimes \mathbf{3} \otimes \left(-\frac{1}{6} + Y_{\phi 1}\right) & \psi 2 \to \overline{\mathbf{10}} \otimes \mathbf{4} \otimes \left(-\frac{1}{3} - Y_{\phi 1}\right) \\
\phi 1 \to \mathbf{15'} \otimes \mathbf{4} \otimes Y_{\phi 1} & \psi 1 \to \mathbf{10} \otimes \mathbf{5} \otimes \left(-\frac{1}{6} + Y_{\phi 1}\right) & \psi 2 \to \overline{\mathbf{10}} \otimes \mathbf{4} \otimes \left(-\frac{1}{3} - Y_{\phi 1}\right) \\
\phi 1 \to \mathbf{15'} \otimes \mathbf{5} \otimes Y_{\phi 1} & \psi 1 \to \mathbf{10} \otimes \mathbf{4} \otimes \left(-\frac{1}{6} + Y_{\phi 1}\right) & \psi 2 \to \overline{\mathbf{10}} \otimes \mathbf{5} \otimes \left(-\frac{1}{3} - Y_{\phi 1}\right)
\end{pmatrix}$$

Using the dictionary

Top-Down: Which Wilson coefficients are generated by a specific UV model?

`Match2Warsaw[op,model]`

```
In[225]:= Limit[Match2Warsaw[alphaOdd[3, 2, 3, 2], {Sa → {3, 3, -1 / 3}, Fa → {3, 3, 2 / 3}}], MFa → MSa] /.
  onelooporder → 1 // NiceOutput
```

$$\text{Out[225]=} \; -\frac{\left(\lambda_{dR,Fa,Sa}{}^{[2]}\right)^2 \left(\bar{\lambda}_{dR,Fa,Sa}{}^{[3]}\right)^2}{64\,\pi^2\,M_{Sa}^2}$$

Only input: representations of the new fields

The dictionary – compute all WCs

Create Lagrangean of UV model:

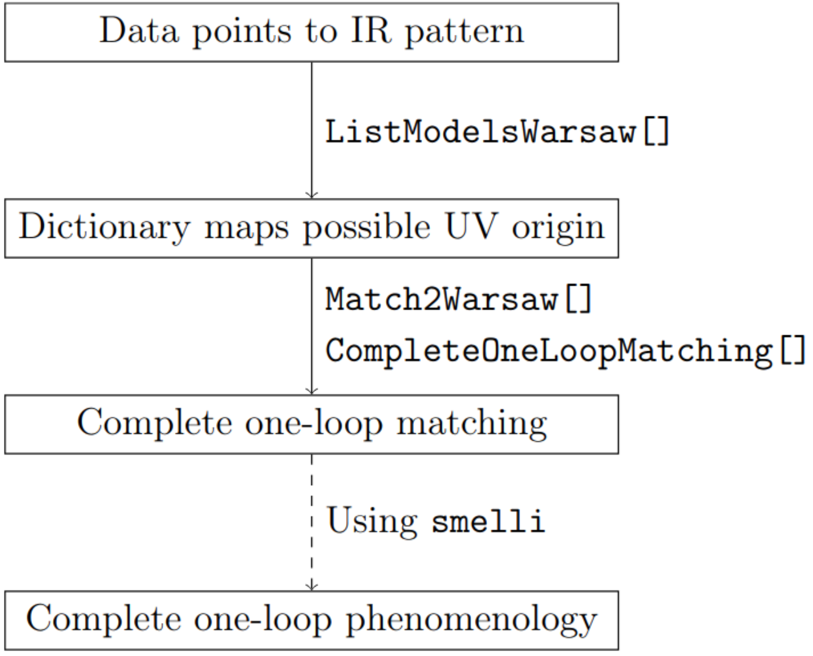
```
In[2]:= CreateLag[{Sa → {{0, 0}, 1, Y1}, Fa → {{0, 1}, 2, -(1/6) + Y1}, Fb → {{1, 0}, 1, -(1/3) - Y1}}]
```

Out[2]= $\{Sa^2\,Sabar^2\,\lambda_{\overline{Sa},\overline{Sa},Sa,Sa}$ + Sa DRbar[sp1, ff0, cc0].Fb[sp1, cc1] $\lambda_{\overline{dR},Fb,Sa}{}^{[ff0]}$ TC51[cc0, cc1] +
Sa Sabar Phi[ss2] × Phibar[ss0] $\lambda_{\overline{\phi},\overline{Sa},\phi,Sa}$ TS11[ss0, ss2] +
CC[Fabar[sp1, ss0, cc0]].left[Fb[sp1, cc1]] × Phi[ss2] $\lambda^{[L]}{}_{Fa,Fb,\phi}$ TC31[cc0, cc1] × TS31[ss0, ss2] +
CC[Fabar[sp1, ss0, cc0]].right[Fb[sp1, cc1]] × Phi[ss2] $\lambda^{[R]}{}_{Fa,Fb,\phi}$ TC31[cc0, cc1] × TS31[ss0, ss2] +
Sabar CC[Fabar[sp1, ss1, cc1]].QL[sp1, ss2, ff0, cc2] $\lambda_{\overline{Sa},Fa,qL}{}^{[ff0]}$ TC41[cc1, cc2] × TS41[ss1, ss2],
{TS11 → {{1, 0}, {0, 1}}, TC31 → {{1, 0, 0}, {0, 1, 0}, {0, 0, 1}}, TS31 → {{0, -1}, {1, 0}},
TC41 → {{1, 0, 0}, {0, 1, 0}, {0, 0, 1}}, TS41 → {{0, -1}, {1, 0}}, TC51 → {{1, 0, 0}, {0, 1, 0}, {0, 0, 1}}}}

Run **Matchmakereft** directly:

```
In[9]:= CompleteOneLoopMatching[{Sa->{{0,0},1,Y1},Fa->{{0,1},2,-(1/6)+Y1},
        Fb->{{1,0},1,-(1/3)-Y1}},"model"]
```

Integrate the dictionary in a pheno study



J. Aebischer, J. Kumar, P. Stangl, D.M. Straub 1810.07698

All these steps can be done within `SOLD`

Automated notebook to translate from `MatchmakerEFT` to `smelli`, `that` could be included in future versions

A very brief example

Can we explain

$$R^K_{\nu\nu} = \frac{\mathcal{B}(B \to K\overline{\nu}\nu)}{\mathcal{B}(B \to K\overline{\nu}\nu)|_{\text{SM}}} = 5.4 \pm 1.5\,.$$

at the loop-level?

F.-Z. Chen, Q. Wen, and F. Xu, 2401.11552

$$\left[C^{(1)}_{\ell q}\right]_{2232} = 6.5 \times 10^{-4} \qquad \left[C^{(1)}_{\ell q}\right]_{3332} = 5.57 \times 10^{-2}$$

$$\left[C^{(3)}_{\ell q}\right]_{3332} = 4.75 \times 10^{-2} \qquad \left[C^{(1)}_{\ell d}\right]_{3332} = 1.87 \times 10^{-2}$$

Which UV can accommodate this pattern?

A very brief example

Which models generate BOTH $\mathcal{O}_{\ell q}$ and $\mathcal{O}_{\ell d}$?

```
In[16]:= modelintersection =
Intersection[ ListModelWarsaw[alphaOld,True][[1]] /.
List[List[a_, b_], c_, d_] /; b > a :> List[List[b, a], c, -d]
/. Sb -> Sa,  ListModelWarsaw[alphaOlq1,True][[1]] /.
  List[List[a_, b_], c_, d_] /; b > a :> List[List[b, a], c, -d] /.
 Sb -> Sa]
```

Let me choose one model that does not work.

$$\text{SM} + \Phi \sim (8,2,1/2) + \Psi\ (8,1,0)$$

```
Limit[Match2Warsaw[
alphaOlq1[3, 3, 3, 2], {Sa -> {8, 2, 1/2},
 Fa -> {8,1,0}}], MFa -> MSa]/.onelooporder->1 // NiceOu
```

```
Limit[Match2Warsaw[
alphaOlq3[3, 3, 3, 2], {Sa -> {8, 2, 1/2},
 Fa -> {8,1,0}}], MFa -> MSa]/.onelooporder->1 // NiceOutput
```

$$\left[C_{\ell q}^{(1)}\right]_{3332} = \frac{\lambda_{\overline{\text{Sa}},\text{Fa},\text{lL}}^{[3]}\bar{\lambda}_{\overline{\text{Sa}},\text{Fa},\text{lL}}^{[3]}\lambda_{\overline{\text{dR}},\text{qL},\text{Sa}}^{[\text{fl1, 2}]}\bar{\lambda}_{\overline{\text{dR}},\text{qL},\text{Sa}}^{[\text{fl1, 3}]}}{192\pi^2 M_{\text{Sa}}^2} - \frac{\bar{\lambda}_{\overline{\text{qL}},\text{Sa},\text{uR}}^{[\text{2, fl1}]}\lambda_{\overline{\text{Sa}},\text{Fa},\text{lL}}^{[3]}\bar{\lambda}_{\overline{\text{Sa}},\text{Fa},\text{lL}}^{[3]}\lambda_{\overline{\text{qL}},\text{Sa},\text{uR}}^{[\text{3, fl1}]}}{192\pi^2 M_{\text{Sa}}^2}$$

$$\left[C_{\ell q}^{(3)}\right]_{3332} = -\frac{\lambda_{\overline{\text{Sa}},\text{Fa},\text{lL}}^{[3]}\bar{\lambda}_{\overline{\text{Sa}},\text{Fa},\text{lL}}^{[3]}\lambda_{\overline{\text{dR}},\text{qL},\text{Sa}}^{[\text{fl1, 2}]}\bar{\lambda}_{\overline{\text{dR}},\text{qL},\text{Sa}}^{[\text{fl1, 3}]}}{192\pi^2 M_{\text{Sa}}^2} - \frac{\bar{\lambda}_{\overline{\text{qL}},\text{Sa},\text{uR}}^{[\text{2, fl1}]}\lambda_{\overline{\text{Sa}},\text{Fa},\text{lL}}^{[3]}\bar{\lambda}_{\overline{\text{Sa}},\text{Fa},\text{lL}}^{[3]}\lambda_{\overline{\text{qL}},\text{Sa},\text{uR}}^{[\text{3, fl1}]}}{192\pi^2 M_{\text{Sa}}^2}.$$

Let me choose one model that does not work:

$$\text{SM} + \Phi \sim (8, 2, 1/2) + \Psi \; (8, 1, 0)$$

```
In[6]:= Limit[Match2Warsaw[alphaOld[3, 3, 3, 2],
            {Sa → {8, 2, 1 / 2}, Fa → {8, 1, 0}}], MFa → MSa] /.
          onelooporder → 1 /. g1 → 0 // Expand // NiceOutput
```

$$\text{Out[6]=} \; -\frac{{\lambda_{\text{Fa,lL,Sa}}}^{[3]} \, {\lambda_{\overline{\text{qL}},\text{dR,Sa}}}^{[\text{fl1},\,2]} \, {\overline{\lambda}_{\text{Fa,lL,Sa}}}^{[3]} \, {\overline{\lambda}_{\overline{\text{qL}},\text{dR,Sa}}}^{[\text{fl1},\,3]}}{96\,\pi^2\,M_{\text{Sa}}^2}$$

$$C_{\ell q}^{(1)} = -C_{\ell q}^{(3)}$$

Conclusions

- UV/IR dictionaries efficiently connect the SMEFT (and therefore observables) with possible UV origins
- Since one-loop effects are relevant, a dictionary at this order should be computed: **SOLD – only package that can go from EFT to UV**
- Future directions: include vectors and non-renormalizable UV? Interface with further packages in the EFT ecosystem.

Thanks

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