DsixTools
The Effective Field Theory Toolkit

In[142]:=
```
Quit[];
```

In[1]:=
```
Needs["DsixTools`"]
```

DsixTools 2.0

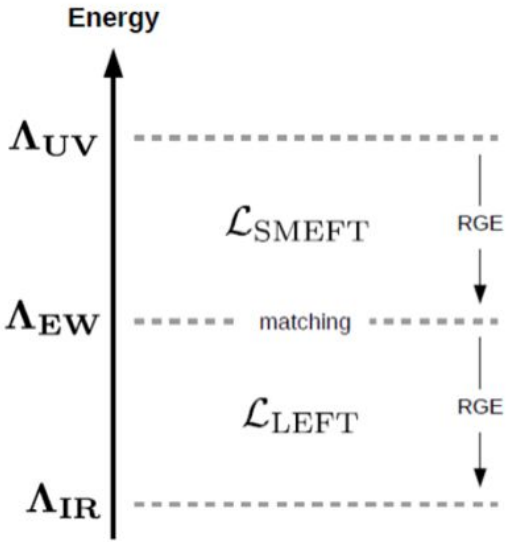
by Alejandro Celis, Javier Fuentes-Martin, Pedro Ruiz-Femenia, Avelino Vicente and Javier Virto
References: arXiv:1704.04504 and arXiv:2010.16341
Website: https://dsixtools.github.io/

1. What is DsixTools?

DSIXTOOLS IS A MATHEMATICA PACKAGE FOR THE MATCHING AND RENORMALIZATION-GROUP EVOLUTION FROM THE NEW PHYSICS SCALE TO THE SCALE OF LOW ENERGY OBSERVABLES

The current version of **DsixTools** includes:

- Three-loop SM RGEs, and five-loop QCD corrections to the running of the strong and quark Yukawa couplings
- Full one-loop RGEs in the SMEFT
- One-loop matching between the SMEFT and the LEFT at the electroweak scale
- Full one-loop QCD and QED running from the electroweak scale down to the scale of B physics
- Repository of analytical expressions for one loop beta functions and matching conditions in Mathematica format
- Comprehensive reference and documentation environment



2. Finding and Installing DsixTools

In[1]:=
```
Import["https://raw.githubusercontent.com/DsixTools/DsixTools/master/install.m"];
```

```
Downloading DsixTools from https://github.com/DsixTools/DsixTools/archive/master.zip
Extracting DsixTools zip file
Copying DsixTools to /Users/javivirto/Library/Mathematica/Applications/DsixTools
Setting up the help system
Installation complete!
```

DsixTools 2.0

by Alejandro Celis, Javier Fuentes-Martin, Pedro Ruiz-Femenia, Avelino Vicente and Javier Virto
References: arXiv:1704.04504 and arXiv:2010.16341
Website: https://dsixtools.github.io/

```
Converting files: m to mx
Conversion complete!
```

3. DsixTools as an EFT Repository

■ SMEFT Lagrangian

$$\mathcal{L}_{\text{SMEFT}} = \mathcal{L}_{\text{SM}} + \sum_k C_k^{(5)} Q_k^{(5)} + \sum_k C_k^{(6)} Q_k^{(6)} + \mathcal{O}\left(\frac{1}{\Lambda_{\text{UV}}^3}\right)$$

In[2]:= `SMEFTOperatorsGrid`

Out[2]=

Q_g	$Q_{g'}$	Q_{g_s}	Q_λ	Q_{m^2}	Q_{Γ_u}	Q_{Γ_d}	Q_{Γ_e}	Q_θ	$Q_{\theta'}$	Q_{θ_s}	Q_G	$Q_{\widetilde{G}}$	Q_W	$Q_{\widetilde{W}}$
Q_φ	$Q_{\varphi\Box}$	$Q_{\varphi D}$	$Q_{\varphi G}$	$Q_{\varphi B}$	$Q_{\varphi W}$	$Q_{\varphi WB}$	$Q_{\varphi\widetilde{G}}$	$Q_{\varphi\widetilde{B}}$	$Q_{\varphi\widetilde{W}}$	$Q_{\varphi\widetilde{W}B}$	$Q_{u\varphi}$	$Q_{d\varphi}$	$Q_{e\varphi}$	Q_{eW}
Q_{eB}	Q_{uG}	Q_{uW}	Q_{uB}	Q_{dG}	Q_{dW}	Q_{dB}	$Q_{\varphi\ell}^{(1)}$	$Q_{\varphi\ell}^{(3)}$	$Q_{\varphi e}$	$Q_{\varphi q}^{(1)}$	$Q_{\varphi q}^{(3)}$	$Q_{\varphi u}$	$Q_{\varphi d}$	$Q_{\varphi ud}$
$Q_{\ell\ell}$	$Q_{qq}^{(1)}$	$Q_{qq}^{(3)}$	$Q_{\ell q}^{(1)}$	$Q_{\ell q}^{(3)}$	Q_{ee}	Q_{uu}	Q_{dd}	Q_{eu}	Q_{ed}	$Q_{ud}^{(1)}$	$Q_{ud}^{(8)}$	$Q_{\ell e}$	$Q_{\ell u}$	$Q_{\ell d}$
Q_{qe}	$Q_{qu}^{(1)}$	$Q_{qu}^{(8)}$	$Q_{qd}^{(1)}$	$Q_{qd}^{(8)}$	$Q_{\ell edq}$	$Q_{quqd}^{(1)}$	$Q_{quqd}^{(8)}$	$Q_{\ell equ}^{(1)}$	$Q_{\ell equ}^{(3)}$	$Q_{duq\ell}$	Q_{qque}	$Q_{qqq\ell}$	Q_{duue}	$Q_{\ell\ell\varphi\varphi}$

In[3]:=
```
SMEFTOperators
```

Out[3]=
```
{Qg, Qgp, Qgs, Qλ, Qm2, QGu[1, 1], QGu[1, 2], QGu[1, 3], QGu[2, 1], QGu[2, 2], QGu[2, 3], QGu[3, 1], QGu[3, 2],
 QGu[3, 3], QGd[1, 1], QGd[1, 2], QGd[1, 3], ··· 1636 ···, Qduue[3, 2, 3, 2], Qduue[3, 2, 3, 3], Qduue[3, 3, 1, 1],
 Qduue[3, 3, 1, 2], Qduue[3, 3, 1, 3], Qduue[3, 3, 2, 1], Qduue[3, 3, 2, 2], Qduue[3, 3, 2, 3], Qduue[3, 3, 3, 1],
 Qduue[3, 3, 3, 2], Qduue[3, 3, 3, 3], QllHH[1, 1], QllHH[1, 2], QllHH[1, 3], QllHH[2, 2], QllHH[2, 3], QllHH[3, 3]}
```

large output | show less | show more | show all | set size limit...

In[15]:=
```
SMEFTParameterList[]
```

Out[15]=
```
{g, gp, gs, λ, m2, Gu[1, 1], Gu[1, 2], Gu[1, 3], Gu[2, 1], Gu[2, 2], Gu[2, 3], Gu[3, 1], Gu[3, 2], Gu[3, 3], Gd[1, 1],
 Gd[1, 2], Gd[1, 3], Gd[2, 1], ··· 1634 ···, Cduue[3, 2, 3, 1], Cduue[3, 2, 3, 2], Cduue[3, 2, 3, 3], Cduue[3, 3, 1, 1],
 Cduue[3, 3, 1, 2], Cduue[3, 3, 1, 3], Cduue[3, 3, 2, 1], Cduue[3, 3, 2, 2], Cduue[3, 3, 2, 3], Cduue[3, 3, 3, 1],
 Cduue[3, 3, 3, 2], Cduue[3, 3, 3, 3], CllHH[1, 1], CllHH[1, 2], CllHH[1, 3], CllHH[2, 2], CllHH[2, 3], CllHH[3, 3]}
```

large output | show less | show more | show all | set size limit...

In[5]:=
```
SMEFTParameterList["D5"]
```

Out[5]=
```
{CllHH[1, 1], CllHH[1, 2], CllHH[1, 3], CllHH[2, 2], CllHH[2, 3], CllHH[3, 3]}
```

In[6]:=
```
SMEFTParameterList["0F"]
```

Out[6]=
```
{g, gp, gs, λ, m2, θ, θp, θs, CG, CGtilde, CW, CWtilde, CH, CHbox, CHD, CHG, CHB, CHW, CHWB, CHGtilde, CHBtilde, CHWtilde, CHWtildeB}
```

In[3]:=
```
SMEFTOperators
```

Out[3]=
```
{Qg, Qgp, Qgs, Qλ, Qm2, QGu[1, 1], QGu[1, 2], QGu[1, 3], QGu[2, 1], QGu[2, 2], QGu[2, 3], QGu[3, 1], QGu[3, 2],
 QGu[3, 3], QGd[1, 1], QGd[1, 2], QGd[1, 3], ··· 1636 ···, Qduue[3, 2, 3, 2], Qduue[3, 2, 3, 3], Qduue[3, 3, 1, 1],
 Qduue[3, 3, 1, 2], Qduue[3, 3, 1, 3], Qduue[3, 3, 2, 1], Qduue[3, 3, 2, 2], Qduue[3, 3, 2, 3], Qduue[3, 3, 3, 1],
 Qduue[3, 3, 3, 2], Qduue[3, 3, 3, 3], QllHH[1, 1], QllHH[1, 2], QllHH[1, 3], QllHH[2, 2], QllHH[2, 3], QllHH[3, 3]}
```

large output | show less | show more | show all | set size limit...

In[15]:=
```
SMEFTParameterList[]
```

Out[15]=
```
{g, gp, gs, λ, m2, Gu[1, 1], Gu[1, 2], Gu[1, 3], Gu[2, 1], Gu[2, 2], Gu[2, 3], Gu[3, 1], Gu[3, 2], Gu[3, 3], Gd[1, 1],
 Gd[1, 2], Gd[1, 3], Gd[2, 1], ··· 1634 ···, Cduue[3, 2, 3, 1], Cduue[3, 2, 3, 2], Cduue[3, 2, 3, 3], Cduue[3, 3, 1, 1],
 Cduue[3, 3, 1, 2], Cduue[3, 3, 1, 3], Cduue[3, 3, 2, 1], Cduue[3, 3, 2, 2], Cduue[3, 3, 2, 3], Cduue[3, 3, 3, 1],
 Cduue[3, 3, 3, 2], Cduue[3, 3, 3, 3], CllHH[1, 1], CllHH[1, 2], CllHH[1, 3], CllHH[2, 2], CllHH[2, 3], CllHH[3, 3]}
```

large output | show less | show more | show all | set size limit...

In[5]:=
```
SMEFTParameterList["D5"]
```

Out[5]=
```
{CllHH[1, 1], CllHH[1, 2], CllHH[1, 3], CllHH[2, 2], CllHH[2, 3], CllHH[3, 3]}
```

In[6]:=
```
SMEFTParameterList["0F"]
```

Out[6]=
```
{g, gp, gs, λ, m2, θ, θp, θs, CG, CGtilde, CW, CWtilde, CH, CHbox, CHD, CHG, CHB, CHW, CHWB, CHGtilde, CHBtilde, CHWtilde, CHWtildeB}
```

In[14]:=
```
SMEFTParameterList["B-violating"] // Short[#, 3] &
```

Out[14]//Short=
```
{Cduql[1, 1, 1, 1], Cduql[1, 1, 1, 2], Cduql[1, 1, 1, 3], Cduql[1, 1, 2, 1],
 Cduql[1, 1, 2, 2], Cduql[1, 1, 2, 3], Cduql[1, 1, 3, 1], <<259>>, Cduue[3, 3, 1, 3], Cduue[3, 3, 2, 1],
 Cduue[3, 3, 2, 2], Cduue[3, 3, 2, 3], Cduue[3, 3, 3, 1], Cduue[3, 3, 3, 2], Cduue[3, 3, 3, 3]}
```

SMEFT beta functions

$$\frac{dC_i}{d\log\mu} \equiv \frac{1}{16\pi^2}\beta_i$$

In[31]:=
```
CHl3[2, 3] // β // Expand // Short[#, 9] &
```

Out[31]//Short=

$$-\frac{17}{3}\,g^2\,\text{CHl3}[2,3] + \frac{2}{3}\,g^2\,\text{Cll}[2,2,2,3] + \frac{2}{3}\,g^2\,\text{Cll}[2,3,3,3] + 2\,g^2\,\text{Clq3}[2,3,1,1] + 2\,g^2\,\text{Clq3}[2,3,2,2] +$$

$$2\,g^2\,\text{Clq3}[2,3,3,3] + \frac{2}{3}\,g^2\,\text{Conjugate}[\text{Cll}[1,2,3,1]] + \text{<<208>>} + 6\,\text{CHl3}[2,3]\,\text{Conjugate}[\text{Gu}[3,1]]\,\text{Gu}[3,1] -$$

$$6\,\text{Clq3}[2,3,3,3]\,\text{Conjugate}[\text{Gu}[3,1]]\,\text{Gu}[3,1] - 6\,\text{Clq3}[2,3,1,3]\,\text{Conjugate}[\text{Gu}[1,2]]\,\text{Gu}[3,2] -$$

$$6\,\text{Clq3}[2,3,2,3]\,\text{Conjugate}[\text{Gu}[2,2]]\,\text{Gu}[3,2] + 6\,\text{CHl3}[2,3]\,\text{Conjugate}[\text{Gu}[3,2]]\,\text{Gu}[3,2] -$$

$$6\,\text{Clq3}[2,3,3,3]\,\text{Conjugate}[\text{Gu}[3,2]]\,\text{Gu}[3,2] - 6\,\text{Clq3}[2,3,1,3]\,\text{Conjugate}[\text{Gu}[1,3]]\,\text{Gu}[3,3] -$$

$$6\,\text{Clq3}[2,3,2,3]\,\text{Conjugate}[\text{Gu}[2,3]]\,\text{Gu}[3,3] + 6\,\text{CHl3}[2,3]\,\text{Conjugate}[\text{Gu}[3,3]]\,\text{Gu}[3,3] - 6\,\text{Clq3}[2,3,3,3]\,\text{Conjugate}[\text{Gu}[3,3]]\,\text{Gu}[3,3]$$

SM Beta functions up to 4 loops :

In[32]:= `gs // β`

Out[32]=

$$-7\,gs^3 - 4.36492\times10^{-7}\,gs^{11}\,\text{LoopParameter}^5 - 8\,\text{CHG}\,gs\,m2 + \text{LoopParameter}^2\left(\frac{9\,g^2\,gs^3}{32\,\pi^2} + \frac{11\,gp^2\,gs^3}{96\,\pi^2} - \frac{13\,gs^5}{8\,\pi^2} - \frac{gs^3\,Gd[3,3]^2}{8\,\pi^2} - \frac{gs^3\,Gu[3,3]^2}{8\,\pi^2}\right) +$$

$$\text{LoopParameter}^3\left(\frac{109\,g^4\,gs^3}{2048\,\pi^4} - \frac{g^2\,gp^2\,gs^3}{2048\,\pi^4} - \frac{2615\,gp^4\,gs^3}{55\,296\,\pi^4} + \frac{21\,g^2\,gs^5}{256\,\pi^4} + \frac{77\,gp^2\,gs^5}{2304\,\pi^4} + \frac{65\,gs^7}{512\,\pi^4} - \frac{93\,g^2\,gs^3\,Gd[3,3]^2}{2048\,\pi^4} - \right.$$

$$\frac{89\,gp^2\,gs^3\,Gd[3,3]^2}{6144\,\pi^4} - \frac{5\,gs^5\,Gd[3,3]^2}{32\,\pi^4} + \frac{15\,gs^3\,Gd[3,3]^4}{256\,\pi^4} + \frac{7\,gs^3\,Gd[3,3]^2\,Ge[3,3]^2}{512\,\pi^4} - \frac{93\,g^2\,gs^3\,Gu[3,3]^2}{2048\,\pi^4} -$$

$$\left.\frac{101\,gp^2\,gs^3\,Gu[3,3]^2}{6144\,\pi^4} - \frac{5\,gs^5\,Gu[3,3]^2}{32\,\pi^4} + \frac{9\,gs^3\,Gd[3,3]^2\,Gu[3,3]^2}{128\,\pi^4} + \frac{7\,gs^3\,Ge[3,3]^2\,Gu[3,3]^2}{512\,\pi^4} + \frac{15\,gs^3\,Gu[3,3]^4}{256\,\pi^4}\right) +$$

$$\text{LoopParameter}^4\left(-0.00151077\,gs^9 + 0.000106272\,gs^7\,Gu[3,3]^2 - 2.28551\times10^{-6}\,gs^3\,\lambda^2\,Gu[3,3]^2 - \right.$$

$$\left.0.0000758416\,gs^5\,Gu[3,3]^4 + 3.80919\times10^{-6}\,gs^3\,\lambda\,Gu[3,3]^4 + 0.0000286863\,gs^3\,Gu[3,3]^6\right)$$

LEFT Lagrangian

$$\mathcal{L}_{\text{LEFT}} = \mathcal{L}_{\text{QCD+QED}} + \sum_k L_k^{(3)} \mathcal{O}_k^{(3)} + \sum_k L_k^{(5)} \mathcal{O}_k^{(5)} + \sum_k L_k^{(6)} \mathcal{O}_k^{(6)} + \mathcal{O}\left(\frac{1}{\Lambda_{\text{EW}}^3}\right)$$

In[4]:= `LEFTOperatorsGrid`

Out[4]=

$\mathcal{O}_{g_s}$	$\mathcal{O}_e$	$\mathcal{O}_{\theta_{QCD}}$	$\mathcal{O}_{\theta_{QED}}$	$\mathcal{O}_{M_\nu}$	$\mathcal{O}_{M_e}$	$\mathcal{O}_{M_u}$	$\mathcal{O}_{M_d}$	$\mathcal{O}_G$	$\mathcal{O}_{\widetilde{G}}$	$\mathcal{O}_{\nu\gamma}$	$\mathcal{O}_{e\gamma}$	$\mathcal{O}_{u\gamma}$	$\mathcal{O}_{d\gamma}$	$\mathcal{O}_{uG}$
$\mathcal{O}_{dG}$	$\mathcal{O}_{\nu\nu}^{V,LL}$	$\mathcal{O}_{ee}^{V,LL}$	$\mathcal{O}_{\nu e}^{V,LL}$	$\mathcal{O}_{\nu u}^{V,LL}$	$\mathcal{O}_{\nu d}^{V,LL}$	$\mathcal{O}_{eu}^{V,LL}$	$\mathcal{O}_{ed}^{V,LL}$	$\mathcal{O}_{\nu edu}^{V,LL}$	$\mathcal{O}_{uu}^{V,LL}$	$\mathcal{O}_{dd}^{V,LL}$	$\mathcal{O}_{ud}^{V1,LL}$	$\mathcal{O}_{ud}^{V8,LL}$	$\mathcal{O}_{ee}^{V,RR}$	$\mathcal{O}_{eu}^{V,RR}$
$\mathcal{O}_{ed}^{V,RR}$	$\mathcal{O}_{uu}^{V,RR}$	$\mathcal{O}_{dd}^{V,RR}$	$\mathcal{O}_{ud}^{V1,RR}$	$\mathcal{O}_{ud}^{V8,RR}$	$\mathcal{O}_{\nu e}^{V,LR}$	$\mathcal{O}_{ee}^{V,LR}$	$\mathcal{O}_{\nu u}^{V,LR}$	$\mathcal{O}_{\nu d}^{V,LR}$	$\mathcal{O}_{eu}^{V,LR}$	$\mathcal{O}_{ed}^{V,LR}$	$\mathcal{O}_{ue}^{V,LR}$	$\mathcal{O}_{de}^{V,LR}$	$\mathcal{O}_{\nu edu}^{V,LR}$	$\mathcal{O}_{uu}^{V1,LR}$
$\mathcal{O}_{uu}^{V8,LR}$	$\mathcal{O}_{ud}^{V1,LR}$	$\mathcal{O}_{ud}^{V8,LR}$	$\mathcal{O}_{du}^{V1,LR}$	$\mathcal{O}_{du}^{V8,LR}$	$\mathcal{O}_{dd}^{V1,LR}$	$\mathcal{O}_{dd}^{V8,LR}$	$\mathcal{O}_{ee}^{V1,LR}$	$\mathcal{O}_{ee}^{V8,LR}$	$\mathcal{O}_{ee}^{S,RR}$	$\mathcal{O}_{eu}^{S,RR}$	$\mathcal{O}_{eu}^{T,RR}$	$\mathcal{O}_{ed}^{S,RR}$	$\mathcal{O}_{ed}^{T,RR}$	$\mathcal{O}_{\nu edu}^{S,RR}$
$\mathcal{O}_{\nu edu}^{T,RR}$	$\mathcal{O}_{uu}^{S1,RR}$	$\mathcal{O}_{uu}^{S8,RR}$	$\mathcal{O}_{ud}^{S1,RR}$	$\mathcal{O}_{ud}^{S8,RR}$	$\mathcal{O}_{dd}^{S1,RR}$	$\mathcal{O}_{dd}^{S8,RR}$	$\mathcal{O}_{uddu}^{S1,RR}$	$\mathcal{O}_{uddu}^{S8,RR}$	$\mathcal{O}_{eu}^{S,RL}$	$\mathcal{O}_{ed}^{S,RL}$	$\mathcal{O}_{\nu edu}^{S,RL}$	$\mathcal{O}_{\nu\nu}^{S,LL}$	$\mathcal{O}_{\nu e}^{S,LL}$	$\mathcal{O}_{\nu e}^{T,LL}$
$\mathcal{O}_{\nu e}^{S,LR}$	$\mathcal{O}_{\nu u}^{S,LL}$	$\mathcal{O}_{\nu u}^{T,LL}$	$\mathcal{O}_{\nu u}^{S,LR}$	$\mathcal{O}_{\nu d}^{S,LL}$	$\mathcal{O}_{\nu d}^{T,LL}$	$\mathcal{O}_{\nu d}^{S,LR}$	$\mathcal{O}_{\nu edu}^{S,LL}$	$\mathcal{O}_{\nu edu}^{T,LL}$	$\mathcal{O}_{\nu edu}^{S,LR}$	$\mathcal{O}_{\nu edu}^{V,RL}$	$\mathcal{O}_{\nu edu}^{V,RR}$	$\mathcal{O}_{udd}^{S,LL}$	$\mathcal{O}_{duu}^{S,LL}$	$\mathcal{O}_{uud}^{S,LR}$
$\mathcal{O}_{duu}^{S,LR}$	$\mathcal{O}_{uud}^{S,RL}$	$\mathcal{O}_{duu}^{S,RL}$	$\mathcal{O}_{dud}^{S,RL}$	$\mathcal{O}_{ddu}^{S,RL}$	$\mathcal{O}_{duu}^{S,RR}$	$\mathcal{O}_{ddd}^{S,LL}$	$\mathcal{O}_{udd}^{S,LR}$	$\mathcal{O}_{ddu}^{S,LR}$	$\mathcal{O}_{ddd}^{S,LR}$	$\mathcal{O}_{ddd}^{S,RL}$	$\mathcal{O}_{udd}^{S,RR}$	$\mathcal{O}_{ddd}^{S,RR}$		

$(\bar{u}_{Lp}\gamma^\mu d_{Lr})(\bar{d}_{Rs}\gamma_\mu u_{Rt})$

In[33]:=
```
LEFTOperators
```

Out[33]=
```
{OgQCD, OeQED, OϴQCD, OϴQED, OMν[1, 1], OMν[1, 2], OMν[1, 3], OMν[2, 2], OMν[2, 3], OMν[3, 3], OMe[1, 1], OMe[1, 2],
 OMe[1, 3], OMe[2, 1], OMe[2, 2], ··· 3655 ···, OdddSRR[1, 3, 1, 2], OdddSRR[1, 3, 1, 3], OdddSRR[1, 3, 2, 1],
 OdddSRR[1, 3, 2, 2], OdddSRR[1, 3, 2, 3], OdddSRR[1, 3, 3, 1], OdddSRR[1, 3, 3, 2], OdddSRR[1, 3, 3, 3],
 OdddSRR[2, 3, 1, 2], OdddSRR[2, 3, 1, 3], OdddSRR[2, 3, 2, 2], OdddSRR[2, 3, 2, 3], OdddSRR[2, 3, 3, 2], OdddSRR[2, 3, 3, 3]}
```

large output | show less | show more | show all | set size limit...

In[34]:=
```
LEFTParameterList[]
```

Out[34]=
```
{gQCD, eQED, ϴQCD, ϴQED, Mν[1, 1], Mν[1, 2], Mν[1, 3], Mν[2, 2], Mν[2, 3], Mν[3, 3], Me[1, 1], Me[1, 2], Me[1, 3],
 Me[2, 1], Me[2, 2], ··· 3654 ···, LdddSRR[1, 3, 1, 1], LdddSRR[1, 3, 1, 2], LdddSRR[1, 3, 1, 3], LdddSRR[1, 3, 2, 1],
 LdddSRR[1, 3, 2, 2], LdddSRR[1, 3, 2, 3], LdddSRR[1, 3, 3, 1], LdddSRR[1, 3, 3, 2], LdddSRR[1, 3, 3, 3],
 LdddSRR[2, 3, 1, 2], LdddSRR[2, 3, 1, 3], LdddSRR[2, 3, 2, 2], LdddSRR[2, 3, 2, 3], LdddSRR[2, 3, 3, 2], LdddSRR[2, 3, 3, 3]}
```

large output | show less | show more | show all | set size limit...

In[35]:=
```
LEFTParameterList["D5"]
```

Out[35]=
```
{Lvγ[1, 2], Lvγ[1, 3], Lvγ[2, 3], Leγ[1, 1], Leγ[1, 2], Leγ[1, 3], Leγ[2, 1], Leγ[2, 2],
 Leγ[2, 3], Leγ[3, 1], Leγ[3, 2], Leγ[3, 3], Luγ[1, 1], Luγ[1, 2], Luγ[2, 1], Luγ[2, 2], Ldγ[1, 1], Ldγ[1, 2],
 Ldγ[1, 3], Ldγ[2, 1], Ldγ[2, 2], Ldγ[2, 3], Ldγ[3, 1], Ldγ[3, 2], Ldγ[3, 3], LuG[1, 1], LuG[1, 2], LuG[2, 1],
 LuG[2, 2], LdG[1, 1], LdG[1, 2], LdG[1, 3], LdG[2, 1], LdG[2, 2], LdG[2, 3], LdG[3, 1], LdG[3, 2], LdG[3, 3]}
```

In[36]:=
```
LEFTParameterList["2F"]
```

Out[36]=
```
{Mν[1, 1], Mν[1, 2], Mν[1, 3], Mν[2, 2], Mν[2, 3], Mν[3, 3], Me[1, 1], Me[1, 2], Me[1, 3], Me[2, 1], Me[2, 2],
 Me[2, 3], Me[3, 1], Me[3, 2], Me[3, 3], Mu[1, 1], Mu[1, 2], Mu[2, 1], Mu[2, 2], Md[1, 1], Md[1, 2], Md[1, 3], Md[2, 1],
 Md[2, 2], Md[2, 3], Md[3, 1], Md[3, 2], Md[3, 3], LνY[1, 2], LνY[1, 3], LνY[2, 3], LeY[1, 1], LeY[1, 2], LeY[1, 3],
 LeY[2, 1], LeY[2, 2], LeY[2, 3], LeY[3, 1], LeY[3, 2], LeY[3, 3], LuY[1, 1], LuY[1, 2], LuY[2, 1], LuY[2, 2],
 LdY[1, 1], LdY[1, 2], LdY[1, 3], LdY[2, 1], LdY[2, 2], LdY[2, 3], LdY[3, 1], LdY[3, 2], LdY[3, 3], LuG[1, 1], LuG[1, 2],
 LuG[2, 1], LuG[2, 2], LdG[1, 1], LdG[1, 2], LdG[1, 3], LdG[2, 1], LdG[2, 2], LdG[2, 3], LdG[3, 1], LdG[3, 2], LdG[3, 3]}
```

In[42]:=
```
LEFTParameterList["LFV"] // Short[#, 8] &
```

Out[42]//Short=
```
{Me[1, 2], Me[1, 3], Me[2, 1], Me[2, 3], Me[3, 1], Me[3, 2], LeY[1, 2], LeY[1, 3], LeY[2, 1], LeY[2, 3], LeY[3, 1], LeY[3, 2],
 LννVLL[1, 1, 1, 2], LννVLL[1, 1, 1, 3], LννVLL[1, 1, 2, 3], LννVLL[1, 2, 1, 2], LννVLL[1, 2, 1, 3], LννVLL[1, 2, 2, 2],
 LννVLL[1, 2, 2, 3], LννVLL[1, 2, 3, 2], LννVLL[1, 2, 3, 3], <<1114>>, LνeduSRL[2, 1, 3, 1], LνeduSRL[2, 1, 3, 2],
 LνeduSRL[2, 3, 1, 1], LνeduSRL[2, 3, 1, 2], LνeduSRL[2, 3, 2, 1], LνeduSRL[2, 3, 2, 2], LνeduSRL[2, 3, 3, 1], LνeduSRL[2, 3, 3, 2],
 LνeduSRL[3, 1, 1, 1], LνeduSRL[3, 1, 1, 2], LνeduSRL[3, 1, 2, 1], LνeduSRL[3, 1, 2, 2], LνeduSRL[3, 1, 3, 1], LνeduSRL[3, 1, 3, 2],
 LνeduSRL[3, 2, 1, 1], LνeduSRL[3, 2, 1, 2], LνeduSRL[3, 2, 2, 1], LνeduSRL[3, 2, 2, 2], LνeduSRL[3, 2, 3, 1], LνeduSRL[3, 2, 3, 2]}
```

LEFT Matching to SMEFT

In[46]:=
```
ObjectInfo[LedVLL]
```

In[54]:=
```
LedVLL[2, 2, 2, 3] // MatchEW // Short[#, 12] &
```

Out[54]//Short=

$$\text{CHq1}[2,3] - \frac{2\,g^2\,\text{CHq1}[2,3]}{g^2+gp^2} + \frac{541\,g^2\,\text{LoopParameter}\,\text{CHq1}[2,3]}{2592\,\pi^2} + \frac{gp^2\,\text{LoopParameter}\,\text{CHq1}[2,3]}{32\,\pi^2} +$$

$$\text{<<217>>} + \frac{48\,g^5\,\text{LoopParameter}\,\text{Conjugate}[\text{Gu}[3,3]]^5\,\text{CuW}[2,3]\,\text{Log}\left[\frac{8315.18\,\lambda}{\text{m2}\,\text{Conjugate}[\text{Gu}[3,3]]^2}\right]}{\pi^2\left(\sqrt{2}\,g-2\,\text{Conjugate}[\text{Gu}[3,3]]\right)^4\left(\sqrt{2}\,g+2\,\text{Conjugate}[\text{Gu}[3,3]]\right)^4} -$$

$$\frac{72\,g^7\,\text{LoopParameter}\,\text{Conjugate}[\text{Gu}[3,3]]^5\,\text{CuW}[2,3]\,\text{Log}\left[\frac{8315.18\,\lambda}{\text{m2}\,\text{Conjugate}[\text{Gu}[3,3]]^2}\right]}{\left(g^2+gp^2\right)\pi^2\left(\sqrt{2}\,g-2\,\text{Conjugate}[\text{Gu}[3,3]]\right)^4\left(\sqrt{2}\,g+2\,\text{Conjugate}[\text{Gu}[3,3]]\right)^4} -$$

$$\frac{56\,g^3\,\text{LoopParameter}\,\text{Conjugate}[\text{Gu}[3,3]]^7\,\text{CuW}[2,3]\,\text{Log}\left[\frac{8315.18\,\lambda}{\text{m2}\,\text{Conjugate}[\text{Gu}[3,3]]^2}\right]}{\pi^2\left(\sqrt{2}\,g-2\,\text{Conjugate}[\text{Gu}[3,3]]\right)^4\left(\sqrt{2}\,g+2\,\text{Conjugate}[\text{Gu}[3,3]]\right)^4} +$$

$$\frac{80\,g^5\,\text{LoopParameter}\,\text{Conjugate}[\text{Gu}[3,3]]^7\,\text{CuW}[2,3]\,\text{Log}\left[\frac{8315.18\,\lambda}{\text{m2}\,\text{Conjugate}[\text{Gu}[3,3]]^2}\right]}{\left(g^2+gp^2\right)\pi^2\left(\sqrt{2}\,g-2\,\text{Conjugate}[\text{Gu}[3,3]]\right)^4\left(\sqrt{2}\,g+2\,\text{Conjugate}[\text{Gu}[3,3]]\right)^4}$$

In[55]:=
```
% /. LoopParameter → 0
```

Out[55]=
$$\text{CHq1}[2,3] - \frac{2\,g^2\,\text{CHq1}[2,3]}{g^2+gp^2} + \text{CHq3}[2,3] - \frac{2\,g^2\,\text{CHq3}[2,3]}{g^2+gp^2} + \text{Clq1}[2,2,2,3] + \text{Clq3}[2,2,2,3]$$

In[57]:=
```
LveduVLL // ObjectInfo
```

In[98]:=
```
LveduVLL[3, 3, 3, 3] // MatchEW // ReplaceAll[LoopParameter → 0] // Simplify // Expand
```

Out[98]=
$$\frac{3\,\mathrm{CH}}{\lambda} - \frac{\lambda}{\mathrm{m2}} - 2\,\mathrm{CHl3}[3,3] - 2\,\mathrm{CHq3}[3,3] + 2\,\mathrm{Clq3}[3,3,3,3]$$

$$\left[L^{V,LL}_{\nu edu}(\mu_{\rm EW})\right]_{iixk} \;=\; -\frac{2}{v^2}\,V^*_{kx} + 2V^*_{jx}\left[C^{(3)}_{\ell q}\right]_{iijk} - 2V^*_{jx}\left[C^{(3)}_{Hq}\right]^*_{kj} - 2V^*_{kx}\left[C^{(3)}_{H\ell}\right]_{ii}$$

$$d_{L,i} = V_{ix}\,d_{L,x} = V_{id}\,d_L + V_{is}\,s_L + V_{ib}\,b_L\ , \qquad i = 1,2,3$$

--(From 1812.08163)

LEFT beta functions

$$\frac{dL_i}{d\log\mu} = \frac{1}{16\pi^2}\beta_i$$

In[58]:=
```
LedVLL[2, 2, 2, 3] // β
```

Out[58]=
$$\frac{8}{9}\,\text{eQED}^2\,\text{Conjugate}[\text{LddVLL}[1,2,3,1]] + \frac{4}{3}\,\text{eQED}^2\,\text{LddV1LR}[2,3,1,1] + \frac{4}{3}\,\text{eQED}^2\,\text{LddV1LR}[2,3,2,2] +$$
$$\frac{4}{3}\,\text{eQED}^2\,\text{LddV1LR}[2,3,3,3] + \frac{8}{3}\,\text{eQED}^2\,\text{LddVLL}[1,1,2,3] + \frac{32}{9}\,\text{eQED}^2\,\text{LddVLL}[2,2,2,3] + \frac{32}{9}\,\text{eQED}^2\,\text{LddVLL}[2,3,3,3] +$$
$$\frac{4}{3}\,\text{eQED}^2\,\text{LdeVLR}[2,3,1,1] + \frac{4}{3}\,\text{eQED}^2\,\text{LdeVLR}[2,3,2,2] + \frac{4}{3}\,\text{eQED}^2\,\text{LdeVLR}[2,3,3,3] - \frac{64}{27}\,\text{eQED}^2\,\text{Conjugate}[\text{LdG}[3,1]]\,\text{LdG}[2,1] -$$
$$\frac{32}{3}\,\text{eQED}\,\text{gQCD}\,\text{Conjugate}[\text{Ld}\gamma[3,1]]\,\text{LdG}[2,1] - \frac{64}{27}\,\text{eQED}^2\,\text{Conjugate}[\text{LdG}[3,2]]\,\text{LdG}[2,2] - \frac{32}{3}\,\text{eQED}\,\text{gQCD}\,\text{Conjugate}[\text{Ld}\gamma[3,2]]\,\text{LdG}[2,2] -$$
$$\frac{64}{27}\,\text{eQED}^2\,\text{Conjugate}[\text{LdG}[3,3]]\,\text{LdG}[2,3] - \frac{32}{3}\,\text{eQED}\,\text{gQCD}\,\text{Conjugate}[\text{Ld}\gamma[3,3]]\,\text{LdG}[2,3] - \frac{8}{3}\,\text{eQED}^2\,\text{LduV1LR}[2,3,1,1] -$$
$$\frac{8}{3}\,\text{eQED}^2\,\text{LduV1LR}[2,3,2,2] - \frac{32}{3}\,\text{eQED}\,\text{gQCD}\,\text{Conjugate}[\text{LdG}[3,1]]\,\text{Ld}\gamma[2,1] + \frac{248}{9}\,\text{eQED}^2\,\text{Conjugate}[\text{Ld}\gamma[3,1]]\,\text{Ld}\gamma[2,1] -$$
$$\frac{32}{3}\,\text{eQED}\,\text{gQCD}\,\text{Conjugate}[\text{LdG}[3,2]]\,\text{Ld}\gamma[2,2] + \frac{248}{9}\,\text{eQED}^2\,\text{Conjugate}[\text{Ld}\gamma[3,2]]\,\text{Ld}\gamma[2,2] -$$
$$\frac{32}{3}\,\text{eQED}\,\text{gQCD}\,\text{Conjugate}[\text{LdG}[3,3]]\,\text{Ld}\gamma[2,3] + \frac{248}{9}\,\text{eQED}^2\,\text{Conjugate}[\text{Ld}\gamma[3,3]]\,\text{Ld}\gamma[2,3] + \frac{4}{3}\,\text{eQED}^2\,\text{LedVLL}[1,1,2,3] +$$
$$\frac{16}{3}\,\text{eQED}^2\,\text{LedVLL}[2,2,2,3] + \frac{4}{3}\,\text{eQED}^2\,\text{LedVLL}[3,3,2,3] - \frac{8}{3}\,\text{eQED}^2\,\text{LudV1LL}[1,1,2,3] - \frac{8}{3}\,\text{eQED}^2\,\text{LudV1LL}[2,2,2,3]$$

SM Beta functions up to 4 loops :

In[59]:= `Md[1, 3] // β`

```
24 Conjugate[LddS1RR[1, 2, 3, 1]] Conjugate[Md[1, 1]] Conjugate[Md[2, 1]] Md[1, 1] +
 20 Conjugate[Md[1, 1]]^2 LddS1RR[1, 1, 1, 3] Md[1, 1] - 4 Conjugate[Md[1, 1]] Conjugate[Md[2, 1]] LddS1RR[1, 1, 2, 3] Md[1, 1] -
 4 Conjugate[Md[1, 1]] Conjugate[Md[3, 1]] LddS1RR[1, 1, 3, 3] Md[1, 1] +
 ··· 2257 ··· + 8 Conjugate[LνdSLL[3, 3, 3, 1]] Conjugate[Mν[2, 3]] Mν[2, 3] Mν[3, 3] +
 8 Conjugate[LνdSLL[2, 3, 3, 1]] Conjugate[Mν[3, 3]] Mν[2, 3] Mν[3, 3] + 4 Conjugate[LνdSLL[3, 3, 3, 1]] Conjugate[Mν[3, 3]] Mν[3, 3]^2 +
 (19325 gQCD^8 LoopParameter^4 Md[1,3] Zeta[3])/(3456 π^6) + (25 gQCD^6 LoopParameter^3 Md[1,3] Zeta[3])/(12 π^4) - (25 gQCD^8 LoopParameter^4 Md[1,3] Zeta[5])/(36 π^6)
```

large output | show less | show more | show all | set size limit...

In[61]:= `gQCD // β // Short[#, 12] &`

Out[61]//Short=

```
-(23 gQCD^3)/3 + (598391 gQCD^9 LoopParameter^4)/(5971968 π^6) - (9769 gQCD^7 LoopParameter^3)/(13824 π^4) - (29 gQCD^5 LoopParameter^2)/(12 π^2) -
 4 gQCD^2 Conjugate[Md[1, 1]] LdG[1, 1] + 4 gQCD Conjugate[Md[1, 1]]^2 LdG[1, 1]^2 - 4 gQCD^2 Conjugate[Md[1, 2]] LdG[1, 2] +
 8 gQCD Conjugate[Md[1, 1]] Conjugate[Md[1, 2]] Ld( , ] LdG[1, 2] + 4 gQCD Conjugate[Md[1, 2]]^2 LdG[1, 2]^2 -
 4 gQCD^2 Conjugate[Md[1, 3]] LdG[1, 3] + 8 gQCD Conjugate[Md[1, 1]] Conjugate[Md[1, 3]] LdG[1, 1] LdG[1, 3] +
 <<143>> + 8 gQCD Conjugate[LuG[1, 1]] Conjugate[LuG[2, 1]] Mu[1, 1] Mu[2, 1] +
 8 gQCD Conjugate[LuG[1, 1]] Conjugate[LuG[2, 2]] Mu[1, 2] Mu[2, 1] + 4 gQCD Conjugate[LuG[2, 1]]^2 Mu[2, 1]^2 -
 4 gQCD^2 Conjugate[LuG[2, 2]] Mu[2, 2] + 8 gQCD Conjugate[LuG[1, 2]] Conjugate[LuG[2, 1]] Mu[1, 1] Mu[2, 2] +
 8 gQCD Conjugate[LuG[1, 2]] Conjugate[LuG[2, 2]] Mu[1, 2] Mu[2, 2] + 8 gQCD Conjugate[LuG[2, 1]] Conjugate[LuG[2, 2]] Mu[2, 1] Mu[2, 2] +
 4 gQCD Conjugate[LuG[2, 2]]^2 Mu[2, 2]^2 - (11027 gQCD^9 LoopParameter^4 Zeta[3])/(10368 π^6)
```

4. Input, Running and Matching

$$\texttt{HIGHSCALE} = \Lambda_{\rm UV} = 10\,\text{TeV}$$

$$\left[C_{\ell q}^{(1)}\right]_{1112} = \left[C_{\ell q}^{(1)}\right]_{1121} = \frac{1}{\Lambda_{\rm UV}^2} = 10^{-8}\ \text{GeV}^{-2}\,, \quad C_\varphi = -\frac{0.5}{\Lambda_{\rm UV}^2} = -5\cdot 10^{-9}\ \text{GeV}^{-2}$$

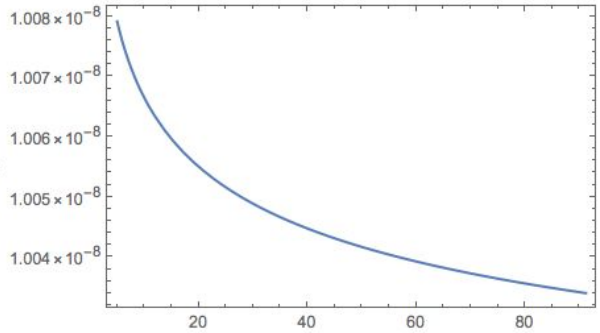
```
In[62]:= NewInput[{Clq1[1, 1, 1, 2] → 1 / HIGHSCALE^2, Clq1[1, 1, 2, 1] → 1 / HIGHSCALE^2, CH → -0.5 / HIGHSCALE^2}, HIGHSCALE → 10000];

In[63]:= RunDsixTools;

In[64]:= D6run[Clq1[1, 1, 1, 2]] /. μ → EWSCALE // Chop
Out[64]= 1.0034 × 10^-8

In[65]:= Plot[D6run[Clq1[1, 1, 1, 2]] // Re, {μ, 5, EWSCALE}, Frame → True]
```

Out[65]=



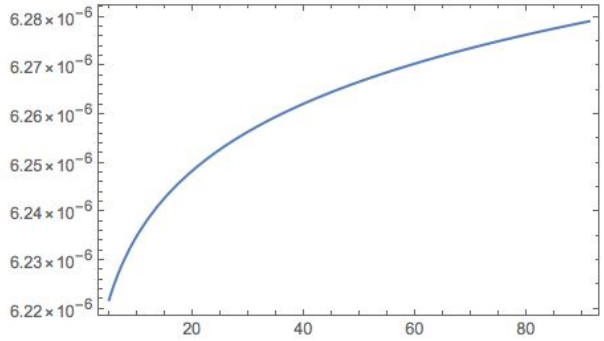
```
D6run[LeuVLL[2, 2, 1, 1]] /. μ → LOWSCALE
```

Out[66]= 6.22183×10^{-6}

$$\left[L_{eu}^{V,LL}\right]_{2211} \simeq 6.22 \cdot 10^{-6}\ \mathrm{GeV}^{-2} \quad \text{at } \mu = 5\ \mathrm{GeV}$$

In[67]:=
```
Plot[D6run[LeuVLL[2, 2, 1, 1]], {μ, 5, EWSCALE}, Frame → True]
```

Out[67]=



5. Working with Lagrangians

EXPLICIT SMEFT and LEFT Lagrangians at different scales for the chosen input:

$$\texttt{HIGHSCALE} = \Lambda_{\rm UV} = 10\,\text{TeV}$$

$$\left[C_{\ell q}^{(1)}\right]_{1112} = \left[C_{\ell q}^{(1)}\right]_{1121} = \frac{1}{\Lambda_{\rm UV}^2} = 10^{-8}\ \text{GeV}^{-2}\,, \quad C_{\varphi} = -\frac{0.5}{\Lambda_{\rm UV}^2} = -5\cdot 10^{-9}\ \text{GeV}^{-2}$$

In[68]:=
```
SMEFTLagrangian[HIGHSCALE]
```

Out[68]=
$$0.651451\,\text{Qg} + 0.357562\,\text{Qgp} + 1.22029\,\text{Qgs} - 5.\times 10^{-9}\,\text{QH} + 8528.18\,\text{Qm2} + 0.281346\,\text{Q}\lambda + 0.000015508\,\text{QGd}[1,1] + 0.000316478\,\text{QGd}[2,2] + 0.0163696\,\text{QGd}[3,3] + 2.93503\times 10^{-6}\,\text{QGe}[1,1] + 0.00060711\,\text{QGe}[2,2] + 0.0102066\,\text{QGe}[3,3] + 7.10857\times 10^{-6}\,\text{QGu}[1,1] - 0.000817532\,\text{QGu}[1,2] + (0.00817608 + 0.00326563\,\text{i})\,\text{QGu}[1,3] + 1.63616\times 10^{-6}\,\text{QGu}[2,1] + 0.00355111\,\text{QGu}[2,2] - 0.040167\,\text{QGu}[2,3] + \left(7.82363\times 10^{-9} + 2.52205\times 10^{-8}\,\text{i}\right)\text{QGu}[3,1] + 0.000153951\,\text{QGu}[3,2] + 0.969815\,\text{QGu}[3,3] + \frac{\text{Qlq1}[1,1,1,2]}{100\,000\,000} + \frac{\text{Qlq1}[1,1,2,1]}{100\,000\,000}$$

In[69]:=
```
SMEFTLagrangian[100]
```

Out[69]=
$$0.650961\,\text{Qg} + 0.357749\,\text{Qgp} + 1.21267\,\text{Qgs} - 3.06672\times 10^{-9}\,\text{QH} + 8555.54\,\text{Qm2} + 0.277172\,\text{Q}\lambda + 0.0000154174\,\text{QGd}[1,1] - \left(1.12361\times 10^{-7} + 4.48791\times 10^{-8}\,\text{i}\right)\text{QGd}[1,3] + 0.000314628\,\text{QGd}[2,2] + 5.52001\times 10^{-7}\,\text{QGd}[2,3] - 1.06494\times 10^{-10}\,\text{QGd}[3,1] + 1.06767\times 10^{-8}\,\text{QGd}[3,2] + 0.0162462\,\text{QGd}[3,3] + 2.9374\times 10^{-6}\,\text{QGe}[1,1] + 0.000607599\,\text{QGe}[2,2] + 0.0102158\,\text{QGe}[3,3] + 7.06649\times 10^{-6}\,\text{QGu}[1,1] - 0.000812693\,\text{QGu}[1,2] + (0.00813436 + 0.00324897\,\text{i})\,\text{QGu}[1,3] + 1.62647\times 10^{-6}\,\text{QGu}[2,1] + 0.00353009\,\text{QGu}[2,2] - 0.039962\,\text{QGu}[2,3] + \left(7.7773\times 10^{-9} + 2.50723\times 10^{-8}\,\text{i}\right)\text{QGu}[3,1] + \left(0.000153039 + 2.24402\times 10^{-9}\,\text{i}\right)\text{QGu}[3,2] + 0.96417\,\text{QGu}[3,3] + 1.00329\times 10^{-8}\,\text{Qlq1}[1,1,1,2] + 1.00329\times 10^{-8}\,\text{Qlq1}[1,1,2,1] - 3.70208\times 10^{-10}\,\text{Qlq3}[1,1,1,2] - 3.70208\times 10^{-10}\,\text{Qlq3}[1,1,2,1]$$

In[73]:=
```
LEFTLagrangian[EWSCALE] // Chop[#, 10^-5] &
```

Out[73]=
```
0.313906 OeQED + 1.22502 OgQCD + 0.00274561 OMd[1, 1] + 0.0560306 OMd[2, 2] + 2.89096 OMd[3, 3] + 0.000519501 OMe[1, 1] +
 0.107458 OMe[2, 2] + 1.80656 OMe[3, 3] + 0.00129122 OMu[1, 1] + 0.645612 OMu[2, 2] - 0.0000119243 OudV1LL[1, 2, 2, 1] -
 0.0000119243 OudV1LL[2, 1, 1, 2] - 0.0000590537 OudV8LL[1, 1, 1, 1] - 0.0000139274 OudV8LL[1, 1, 1, 2] - 0.0000139274 OudV8LL[1, 1, 2, 1] +
 0.0000139176 OudV8LL[1, 2, 1, 1] - 0.0000604542 OudV8LL[1, 2, 2, 1] - 0.0000139148 OudV8LL[1, 2, 2, 2] + 0.0000139176 OudV8LL[2, 1, 1, 1] -
 0.0000604542 OudV8LL[2, 1, 1, 2] - 0.0000139148 OudV8LL[2, 1, 2, 2] + 0.0000139051 OudV8LL[2, 2, 1, 2] + 0.0000139051 OudV8LL[2, 2, 2, 1] -
 0.0000589449 OudV8LL[2, 2, 2, 2] + 0.0000140204 OvdVLL[1, 1, 1, 1] + 0.0000140199 OvdVLL[1, 1, 2, 2] + 0.0000137456 OvdVLL[1, 1, 3, 3] +
 0.0000140204 OvdVLL[2, 2, 1, 1] + 0.0000140199 OvdVLL[2, 2, 2, 2] + 0.0000137456 OvdVLL[2, 2, 3, 3] + 0.0000140204 OvdVLL[3, 3, 1, 1] +
 0.0000140199 OvdVLL[3, 3, 2, 2] + 0.0000137456 OvdVLL[3, 3, 3, 3] - 0.0000316546 OveduVLL[1, 1, 1, 1] - 0.0000316257 OveduVLL[1, 1, 2, 2] -
 0.0000316544 OveduVLL[2, 2, 1, 1] - 0.0000316259 OveduVLL[2, 2, 2, 2] - 0.0000316544 OveduVLL[3, 3, 1, 1] -
 0.0000316259 OveduVLL[3, 3, 2, 2] - 0.0000235362 OveVLL[1, 1, 1, 1] - 0.0000325572 OveVLL[1, 2, 2, 1] - 0.0000325572 OveVLL[1, 3, 3, 1] -
 0.0000325572 OveVLL[2, 1, 1, 2] - 0.0000235362 OveVLL[2, 2, 2, 2] - 0.0000325572 OveVLL[2, 3, 3, 2] - 0.0000325572 OveVLL[3, 1, 1, 3] -
 0.0000325572 OveVLL[3, 2, 2, 3] - 0.0000235362 OveVLL[3, 3, 3, 3] - 0.0000113409 OvuVLL[1, 1, 1, 1] - 0.0000113493 OvuVLL[1, 1, 2, 2] -
 0.0000113451 OvuVLL[2, 2, 1, 1] - 0.0000113451 OvuVLL[2, 2, 2, 2] - 0.0000113451 OvuVLL[3, 3, 1, 1] - 0.0000113451 OvuVLL[3, 3, 2, 2]
```

In[75]:=
```
LEFTLagrangian[5] // Chop // Chop[#, 10^-5] &
```

Out[75]=
```
0.308969 OeQED + 1.65519 OgQCD + 0.0039138 OMd[1, 1] + 0.0798703 OMd[2, 2] + 4.12102 OMd[3, 3] + 0.000525089 OMe[1, 1] +
 0.108614 OMe[2, 2] + 1.826 OMe[3, 3] + 0.00184718 OMu[1, 1] + 0.923594 OMu[2, 2] - 0.0000652001 OudV8LL[1, 1, 1, 1] -
 0.0000151896 OudV8LL[1, 1, 1, 2] - 0.0000151896 OudV8LL[1, 1, 2, 1] + 0.0000151795 OudV8LL[1, 2, 1, 1] - 0.0000659356 OudV8LL[1, 2, 2, 1] -
 0.0000151765 OudV8LL[1, 2, 2, 2] + 0.0000151795 OudV8LL[2, 1, 1, 1] - 0.0000659356 OudV8LL[2, 1, 1, 2] - 0.0000151765 OudV8LL[2, 1, 2, 2] +
 0.0000151663 OudV8LL[2, 2, 1, 2] + 0.0000151663 OudV8LL[2, 2, 2, 1] - 0.0000650838 OudV8LL[2, 2, 2, 2] +
 0.0000139972 OvdVLL[1, 1, 1, 1] + 0.0000139968 OvdVLL[1, 1, 2, 2] + 0.0000137225 OvdVLL[1, 1, 3, 3] + 0.0000139972 OvdVLL[2, 2, 1, 1] +
 0.0000139968 OvdVLL[2, 2, 2, 2] + 0.0000137225 OvdVLL[2, 2, 3, 3] + 0.0000139972 OvdVLL[3, 3, 1, 1] + 0.0000139968 OvdVLL[3, 3, 2, 2] +
 0.0000137225 OvdVLL[3, 3, 3, 3] - 0.0000318657 OveduVLL[1, 1, 1, 1] - 0.0000318366 OveduVLL[1, 1, 2, 2] -
 0.0000318655 OveduVLL[2, 2, 1, 1] - 0.0000318368 OveduVLL[2, 2, 2, 2] - 0.0000318655 OveduVLL[3, 3, 1, 1] -
 0.0000318368 OveduVLL[3, 3, 2, 2] - 0.0000236058 OveVLL[1, 1, 1, 1] - 0.0000325572 OveVLL[1, 2, 2, 1] - 0.0000325572 OveVLL[1, 3, 3, 1] -
 0.0000325572 OveVLL[2, 1, 1, 2] - 0.0000236058 OveVLL[2, 2, 2, 2] - 0.0000325572 OveVLL[2, 3, 3, 2] - 0.0000325572 OveVLL[3, 1, 1, 3] -
 0.0000325572 OveVLL[3, 2, 2, 3] - 0.0000236058 OveVLL[3, 3, 3, 3] - 0.0000112946 OvuVLL[1, 1, 1, 1] - 0.000011303 OvuVLL[1, 1, 2, 2] -
 0.0000112988 OvuVLL[2, 2, 1, 1] - 0.0000112988 OvuVLL[2, 2, 2, 2] - 0.0000112988 OvuVLL[3, 3, 1, 1] - 0.0000112988 OvuVLL[3, 3, 2, 2]
```

INPUT-INDEPENDENT RUNNING :

In[76]:=
```
SMEFTEvolve[CHbox, EWSCALE, HIGHSCALE] // Chop[#, 10^-2] &
```

Out[76]=
```
0.764769 CHbox - 0.0205702 CHl3[1, 1] - 0.0205701 CHl3[2, 2] - 0.0205542 CHl3[3, 3] - 0.0885367 CHq1[3, 3] - 0.0616826 CHq3[1, 1] -
 0.0611255 CHq3[2, 2] - 0.0267112 CHq3[2, 3] + 0.245069 CHq3[3, 3] + 0.0883179 CHu[3, 3] + 0.0199374 Cqq1[3, 3, 3, 3] -
 0.0150423 Cqq3[1, 1, 3, 3] - 0.0149066 Cqq3[2, 2, 3, 3] + 0.0318523 Cqq3[3, 3, 3, 3] - 0.0136106 Cqu1[3, 3, 3, 3] + 0.01659 Cuu[3, 3, 3, 3]
```

In[77]:=
```
LEFTEvolve[LuuVLL, LOWSCALE] // Chop[#, 10^-3] &
```

Out[77]=
```
0.00132172 LeuVLL[1, 1, 1, 1] + 0.00132172 LeuVLL[2, 2, 1, 1] + 0.00132172 LeuVLL[3, 3, 1, 1] +
 0.00291212 LudV1LL[1, 1, 1, 1] + 0.00291212 LudV1LL[1, 1, 2, 2] + 0.00291212 LudV1LL[1, 1, 3, 3] -
 0.00704604 LudV8LL[1, 1, 1, 1] - 0.00704604 LudV8LL[1, 1, 2, 2] - 0.00704604 LudV8LL[1, 1, 3, 3] - 0.0084454 LudV8LR[1, 1, 1, 1] -
 0.0084454 LudV8LR[1, 1, 2, 2] - 0.0084454 LudV8LR[1, 1, 3, 3] + 0.00130363 LueVLR[1, 1, 1, 1] + 0.00130363 LueVLR[1, 1, 2, 2] +
 0.00130363 LueVLR[1, 1, 3, 3] - 0.00447332 LuuV1LR[1, 1, 1, 1] - 0.00447332 LuuV1LR[1, 1, 2, 2] - 0.00872681 LuuV8LR[1, 1, 1, 1] -
 0.00872681 LuuV8LR[1, 1, 2, 2] + 0.827456 LuuVLL[1, 1, 1, 1] - 0.00211675 LuuVLL[1, 1, 2, 2] - 0.0279296 LuuVLL[1, 2, 2, 1]
```

LEFT Lagrangian at any scale in the SM:

In[78]:=
```
SetSMLEFTInput
```

In[80]:=
```
LEFTLagrangian[EWSCALE] // Chop[#, 10^-5] &
```

Out[80]=
```
0.313905 OeQED + 1.22503 OgQCD + 0.00274718 OMd[1, 1] + 0.0560627 OMd[2, 2] + 2.89261 OMd[3, 3] + 0.000519799 OMe[1, 1] +
 0.10752 OMe[2, 2] + 1.8076 OMe[3, 3] + 0.00129196 OMu[1, 1] + 0.645983 OMu[2, 2] - 0.0000119147 OudV1LL[1, 2, 2, 1] -
 0.0000119147 OudV1LL[2, 1, 1, 2] - 0.0000589837 OudV8LL[1, 1, 1, 1] - 0.0000139109 OudV8LL[1, 1, 1, 2] - 0.0000139109 OudV8LL[1, 1, 2, 1] +
 0.0000139012 OudV8LL[1, 2, 1, 1] - 0.000060383 OudV8LL[1, 2, 2, 1] - 0.0000138984 OudV8LL[1, 2, 2, 2] + 0.0000139012 OudV8LL[2, 1, 1, 1] -
 0.000060383 OudV8LL[2, 1, 1, 2] - 0.0000138984 OudV8LL[2, 1, 2, 2] + 0.0000138887 OudV8LL[2, 2, 1, 2] + 0.0000138887 OudV8LL[2, 2, 2, 1] -
 0.000058875 OudV8LL[2, 2, 2, 2] + 0.0000140045 OνdVLL[1, 1, 1, 1] + 0.0000140041 OνdVLL[1, 1, 2, 2] + 0.00001373 OνdVLL[1, 1, 3, 3] +
 0.0000140045 OνdVLL[2, 2, 1, 1] + 0.0000140041 OνdVLL[2, 2, 2, 2] + 0.00001373 OνdVLL[2, 2, 3, 3] + 0.0000140045 OνdVLL[3, 3, 1, 1] +
 0.0000140041 OνdVLL[3, 3, 2, 2] + 0.00001373 OνdVLL[3, 3, 3, 3] - 0.0000316183 OνeduVLL[1, 1, 1, 1] - 0.0000315899 OνeduVLL[1, 1, 2, 2] -
 0.0000316183 OνeduVLL[2, 2, 1, 1] - 0.0000315899 OνeduVLL[2, 2, 2, 2] - 0.0000316183 OνeduVLL[3, 3, 1, 1] -
 0.0000315899 OνeduVLL[3, 3, 2, 2] - 0.0000235095 OνeVLL[1, 1, 1, 1] - 0.0000325203 OνeVLL[1, 2, 2, 1] - 0.0000325203 OνeVLL[1, 3, 3, 1] -
 0.0000325203 OνeVLL[2, 1, 1, 2] - 0.0000235095 OνeVLL[2, 2, 2, 2] - 0.0000325203 OνeVLL[2, 3, 3, 2] - 0.0000325203 OνeVLL[3, 1, 1, 3] -
 0.0000325203 OνeVLL[3, 2, 2, 3] - 0.0000235095 OνeVLL[3, 3, 3, 3] - 0.0000113323 OνuVLL[1, 1, 1, 1] - 0.0000113323 OνuVLL[1, 1, 2, 2] -
 0.0000113323 OνuVLL[2, 2, 1, 1] - 0.0000113323 OνuVLL[2, 2, 2, 2] - 0.0000113323 OνuVLL[3, 3, 1, 1] - 0.0000113323 OνuVLL[3, 3, 2, 2]
```

6. Full Mathematica Documentation

Click F1 on top of :

```
DsixTools
```

See papers and documentation for further details

Artwork

Mixing among all SMEFT Leptonic Four-Fermion operators (Qll, Qee, Qle):

```
LeptOps = Position[SMEFTParameterList[], Cll | Cle | Cee][[All, 1]];
ArrayPlot[ParallelTable[(Coefficient[β[SMEFTParameterList[][[i]]] /. SubRedundant, SMEFTParameterList[][[j]]] === 0) /.
    {True → 0, False → 1}, {i, LeptOps}, {j, LeptOps}]]
```