Computing tools for the SMEFT

- Matching to specific UV models -

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Siegen
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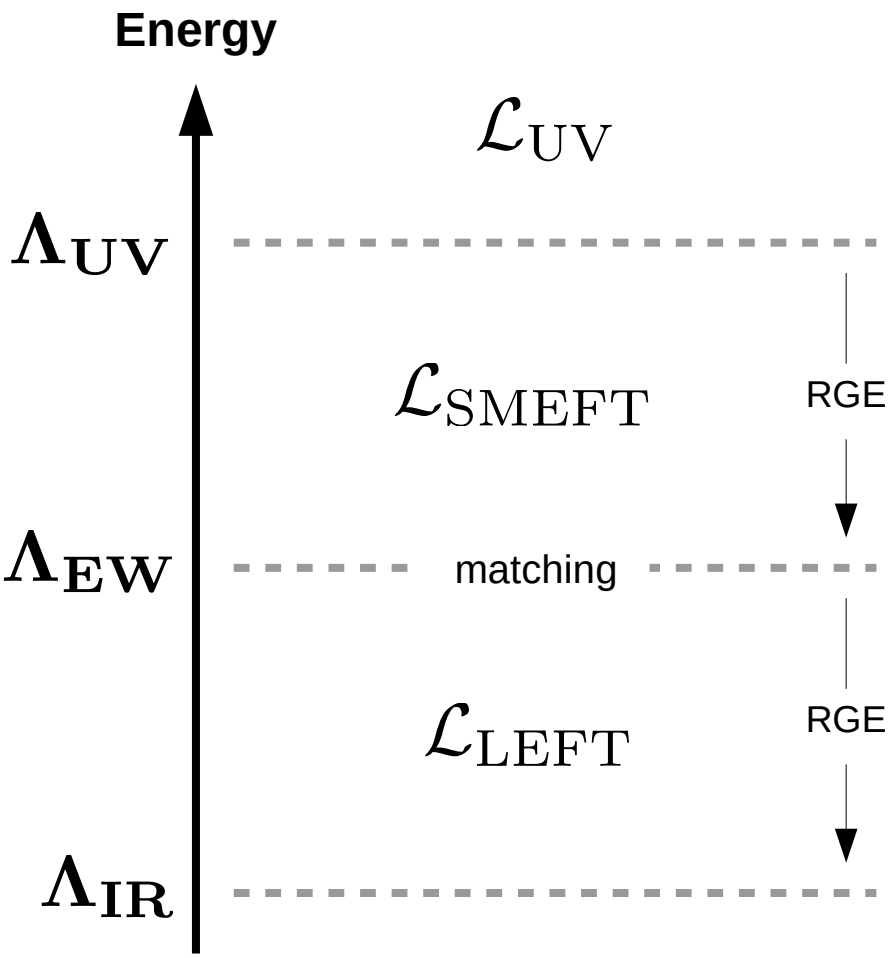
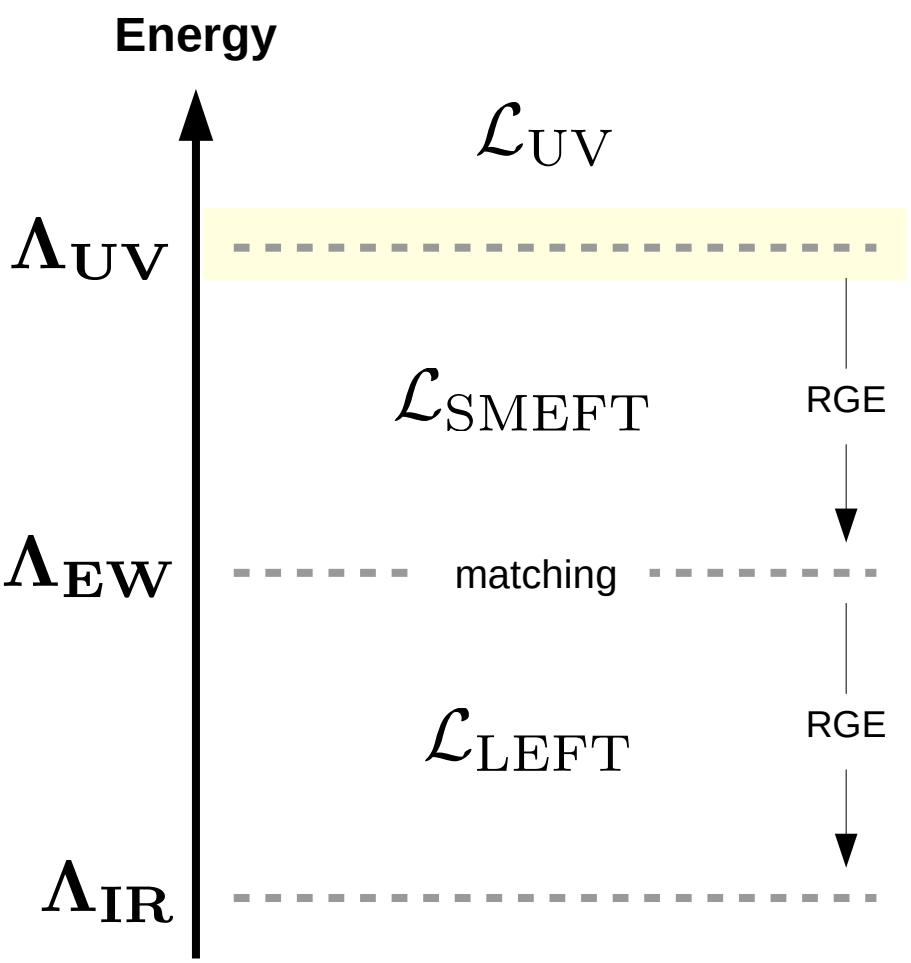
Problem we want to solve



Problem we want to solve



UV model

New fields and Lagrangian terms

Matching

Heavy analytical work

especially if at 1-loop

Reduction to physical basis

Warsaw, for instance

Cross-checks

MatchMakerEFT

MatchMakerEFT is a fully automated tool to perform tree-level and 1-loop matching of arbitrary UV models onto arbitrary effective field theories in the diagrammatic approach.

Adrián Carmona, Achilleas Lazopoulos, Pablo Olgoso, José Santiago

- https://ftae.ugr.es/matchmakereft/
- arXiv:2112.10787
- Python package
- Installation: pip/conda
- It requires **Python** 3.5+, **Mathematica** 10+, **FORM**, **QGRAF** and **FeynRules**
- Alternative: **Matchete** (also **CoDEx** or **MatchingTools**)

What MME can do for you

- Tree-level and 1-loop matching to arbitrary UV models
- RGE computation for arbitrary EFTs
- Basis translation between two bases of an EFT

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Some limitations in its current version (1.0.2)...

- Flavor indices for heavy particles are not supported
- Complicated models (extended gauge sector, non-canonical mass terms, ...) can be complicated to implement
- The calculation of amplitudes with many external legs can be very slow

... but also a very ambitious code with many improvements to come.

Special thanks to **José Santiago** for his assistance when learning how to use **MME**

The SiegeN model

right-handed neutrino

	N	S
$\mathrm{SU(3)_c}$	**1**	**3**
$\mathrm{SU(2)_L}$	**1**	**2**
$\mathrm{U(1)_Y}$	0	$\frac{1}{6}$
GENERATIONS	1	1

scalar leptoquark

$$\mathcal{L} = \mathcal{L}_{\rm SM} + \mathcal{L}_{\rm NP}$$

$$\mathcal{L}_{\rm NP} = \mathcal{L}_N + \mathcal{L}_S + \mathcal{L}_{SH} + \mathcal{L}_{\rm Y}$$

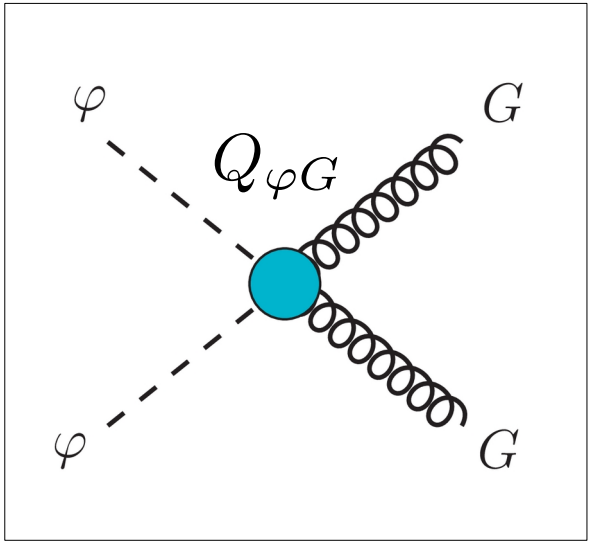
$$\mathcal{L}_N = i\overline{N}\,\gamma_\mu D^\mu N - \frac{1}{2} M_N\,\overline{N^c}\,N$$

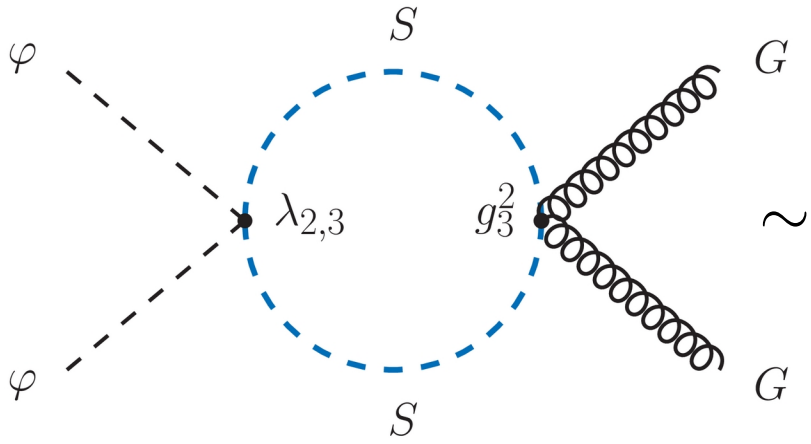
$$\mathcal{L}_S = D_\mu S^\dagger\, D^\mu S - M_S^2\, S^\dagger\, S$$

$$\mathcal{L}_{SH} = -\lambda_2\, H^\dagger H\, S^\dagger S - \lambda_3\, H^\dagger S\, S^\dagger H$$

$$\mathcal{L}_{\rm Y} = -Y_N^\alpha\,\overline{N}\,\ell_L^\alpha H - Y_S^\alpha\,\overline{q}_L^\alpha\, NS + \text{h.c.}$$

$$Q_{\varphi G} = \varphi^\dagger \varphi \, G^A_{\mu\nu} G^{A\mu\nu}$$



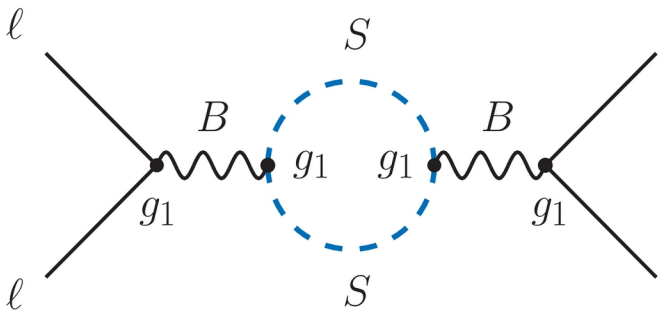


$$\sim \frac{g_3^2 \, \lambda_{2,3}}{16\pi^2 \, M_S^2}$$

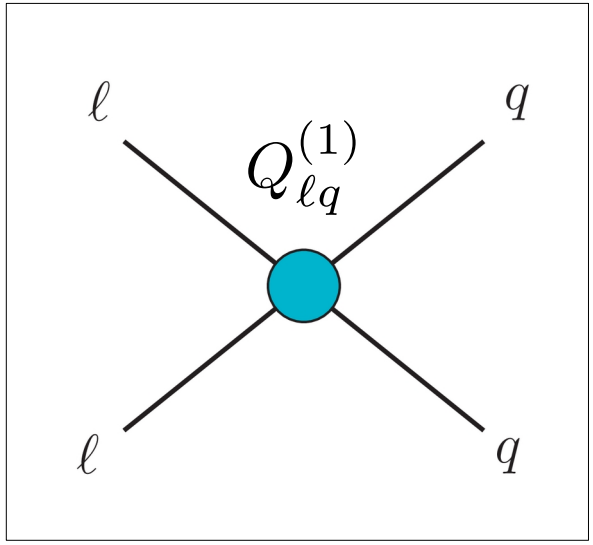
Chuck Norris fact of the day

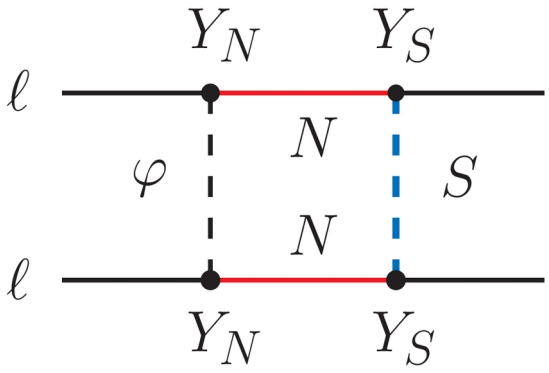
Chuck Norris lost his virginity before his dad

$$Q^{(1)}_{\ell q} = \left(\bar{\ell}\gamma_\mu \ell\right)\left(\bar{q}\gamma^\mu q\right)$$

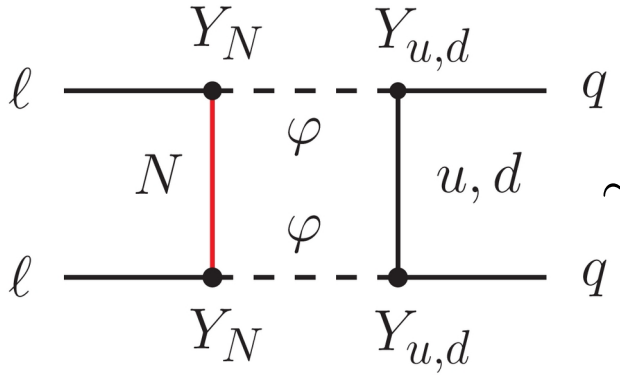


$$\sim \frac{g_1^4}{16\pi^2\, M_S^2}$$

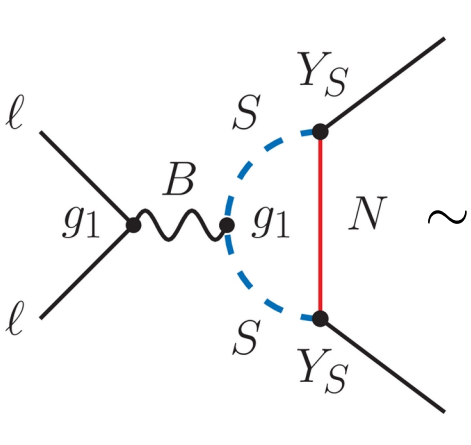




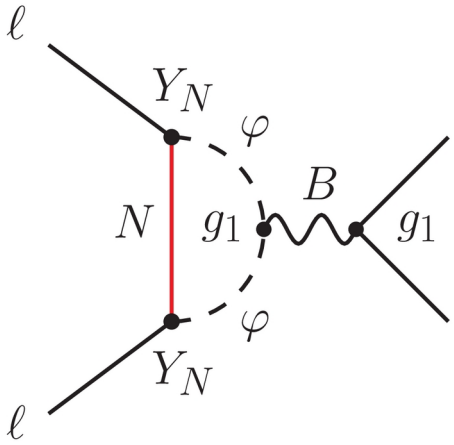
$$\sim \frac{Y_N^2\, Y_S^2}{16\pi^2\, M_{N,S}^2}$$



$$\sim \frac{Y_N^2\, Y_{u,d}^2}{16\pi^2\, M_N^2}$$

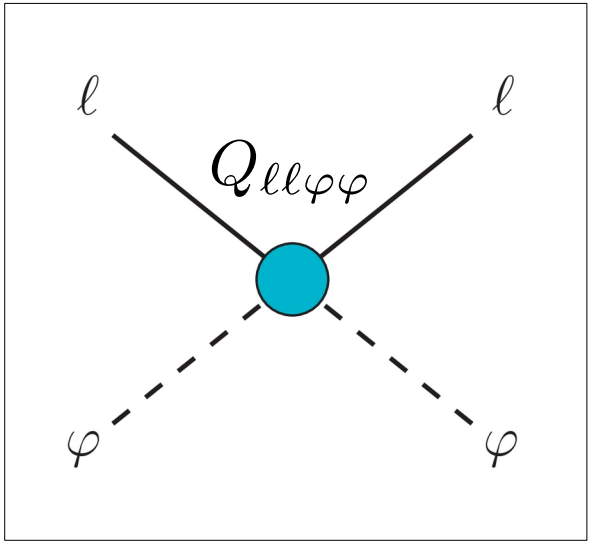


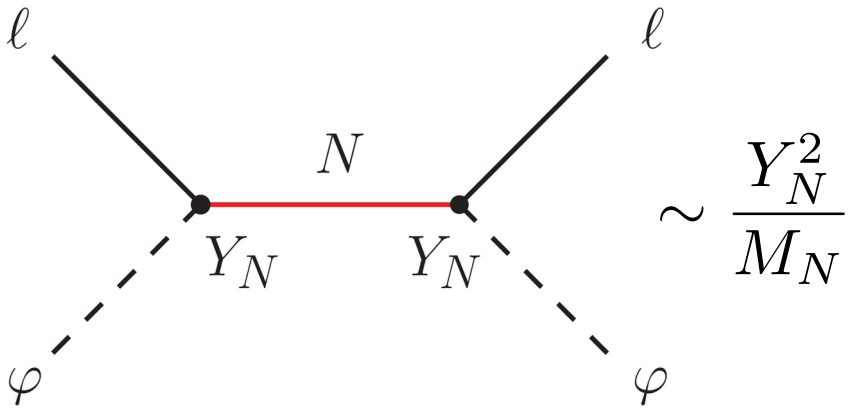
$$\sim \frac{g_1^2\, Y_S^2}{16\pi^2\, M_{N,S}^2}$$



$$\sim \frac{g_1^2\, Y_N^2}{16\pi^2\, M_N^2}$$

$$Q_{\ell\ell\varphi\varphi} = \left(\widetilde{\varphi}^\dagger \ell\right)^T C \left(\widetilde{\varphi}^\dagger \ell\right)$$





Tomorrow

Lecture 3 : RGE running and SMEFT-LEFT matching

DsixTools is a Mathematica package for the matching and RGE evolution from the new physics scale to the scale of low energy observables.

Alejandro Celis, Javier Fuentes-Martín,
Pedro Ruiz-Femenía, Avelino Vicente, Javier Virto

- https://dsixtools.github.io/
- arXiv:1704.04504 and arXiv:2010.16341
- Mathematica package