Short-author paper updates: SMEFT

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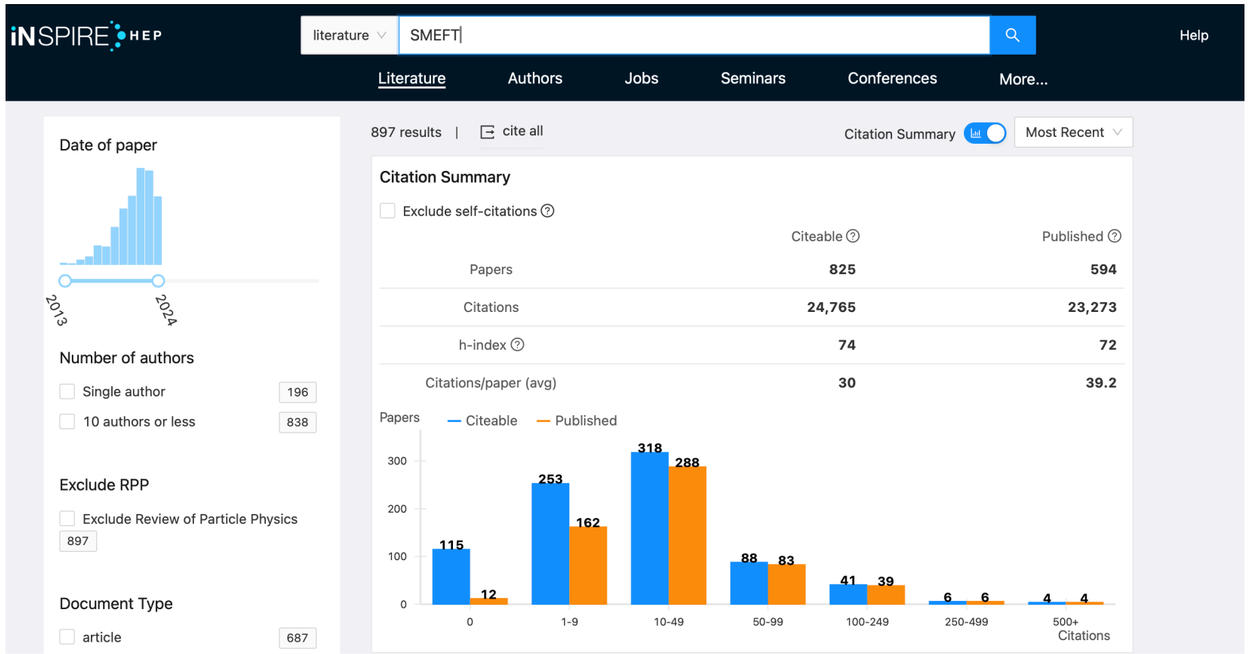
Introduction

We aim in this project to perform a comprehensive global fit of Wilson coefficients generated from the matching of simplified models extending the SM with vector like quarks to SMEFT up to dimension 6

- **Including analyses targeting vector like quark searches at the LHC.**
- **Including flavor observables including top quark FCNC decays.**
- **Including other SM measurements (probably $t\bar{t}, VV \ldots$).**
- **Including Electroweak precision observables.**
- **Including flavor violating observables (top quark FCNC decays in particular).**



Some details

Members (randomly ordered):

- Martin White
- Andreas Crivellin
- Roberto Ruiz de Austri
- Farvah Mahmoudi
- Peter Athron
- Anders Kvellestad
- Tomas Gonzalo
- Christopher Chang
- Pengxuan Zhu
- Tomek
- Adil Jueid

Documentation

Google docs: https://docs.google.com/document/d/1jhOa2F2OGYM2gU-C46pCCs6vcQlxB6abLIK3ecwzdHC
edit?usp=sharing
Overleaf: https://www.overleaf.com/6978394442wwqcspmzkbbr#fa3b3c

Lagrangian

Name	U	D	Q_1	Q_5	Q_7	T_1	T_2
Irrep	$(\mathbf{3},\mathbf{1})_{+2/3}$	$(\mathbf{3},\mathbf{1})_{-1/3}$	$(\mathbf{3},\mathbf{2})_{+1/6}$	$(\mathbf{3},\mathbf{2})_{-5/6}$	$(\mathbf{3},\mathbf{2})_{+7/6}$	$(\mathbf{3},\mathbf{3})_{-1/3}$	$(\mathbf{3},\mathbf{3})_{+2/3}$
	$U^{(+2/3)}$	$D^{(-1/3)}$	$\begin{pmatrix} U^{(+2/3)} \\ D^{(-1/3)} \end{pmatrix}$	$\begin{pmatrix} D^{(-1/3)} \\ Y^{(-4/3)} \end{pmatrix}$	$\begin{pmatrix} X^{(+5/3)} \\ U^{(+2/3)} \end{pmatrix}$	$\begin{pmatrix} U^{(+2/3)} \\ D^{(-1/3)} \\ Y^{(-4/3)} \end{pmatrix}$	$\begin{pmatrix} X^{(+5/3)} \\ U^{(+2/3)} \\ D^{(-1/3)} \end{pmatrix}$

$$
\begin{aligned}
-\mathcal{L}_{\mathrm{Q}}^{\mathrm{int}} &= (\lambda_U)_{ri}\overline{U}_{Rr}\tilde{\phi}^\dagger q_{Li} + (\lambda_D)_{ri}\overline{D}_{Rr}\phi^\dagger q_{Li} \\
&+ (\lambda^u_{Q_1})_{ri}\bar{Q}_{1Lr}\tilde{\phi}u_{Ri} + (\lambda^d_{Q_1})_{ri}\bar{Q}_{1Lr}\phi d_{Ri} \\
&+ (\lambda_{Q_5})_{ri}\bar{Q}_{5Lr}\tilde{\phi}d_{Ri} + (\lambda_{Q_7})_{ri}\bar{Q}_{7Lr}\phi u_{Ri} \\
&= \frac{1}{2}(\lambda_{T_1})_{ri}\bar{T}^a_{1Rr}\phi^\dagger\sigma^a q_{Li} + \frac{1}{2}(\lambda_{T_2})_{ri}\bar{T}^a_{2Rr}\tilde{\phi}^\dagger\sigma^a q_{Li} \\
&+ \mathrm{h.c.} + \mathcal{L}_{\mathrm{mixed}},
\end{aligned}
$$

As a first study we do not need to consider the case where different species of VLQs mix with each other!

A model file for the most model-independent approach is available and working
A branch for this project exists already (smeft_vlq_hacked).

Matching with SMEFT

At Tree level, the VLQs generate the following operators

Fields	Operators
U	$\mathcal{O}_{u\phi}$, $\mathcal{O}_{uB}$, $\mathcal{O}_{uG}$, $\mathcal{O}^{(1)}_{\phi q}$, $\mathcal{O}^{(3)}_{\phi q}$
D	$\mathcal{O}_{d\phi}$, $\mathcal{O}_{dB}$, $\mathcal{O}_{dG}$, $\mathcal{O}^{(1)}_{\phi q}$, $\mathcal{O}^{(3)}_{\phi q}$
Q_1	$\mathcal{O}_{d\phi}$, $\mathcal{O}_{u\phi}$, $\mathcal{O}_{dB}$, $\mathcal{O}_{dW}$, $\mathcal{O}_{dG}$, $\mathcal{O}_{uB}$, $\mathcal{O}_{uW}$, $\mathcal{O}_{uG}$, $\mathcal{O}_{\phi d}$, $\mathcal{O}_{\phi u}$, $\mathcal{O}_{\phi ud}$
Q_5	$\mathcal{O}_{d\phi}$, $\mathcal{O}_{\phi d}$
Q_7	$\mathcal{O}_{u\phi}$, $\mathcal{O}_{\phi u}$
T_1	$\mathcal{O}_{d\phi}$, $\mathcal{O}_{u\phi}$, $\mathcal{O}_{dW}$, $\mathcal{O}^{(1)}_{\phi q}$, $\mathcal{O}^{(3)}_{\phi q}$
T_2	$\mathcal{O}_{d\phi}$, $\mathcal{O}_{u\phi}$, $\mathcal{O}_{uW}$, $\mathcal{O}^{(1)}_{\phi q}$, $\mathcal{O}^{(3)}_{\phi q}$

https://arxiv.org/abs/1711.10391

At the one-loop order, we can generate many more!! There are tools that can be used for this purpose.

LHC searches

Searches for VLQs can be used to constrain the model and therefore the Wilson coefficients.

- **Non resonant searches through SM measurements.**
- **Single production of VLQs (T, X, Y and B).**
- **Pair production of VLQs.**

There are in total 14 ATLAS analyses and 15 CMS analyses.

We start coding about 7 analyses (if I recall correctly). No validation is done so far.

There are many signal regions in total and many different strategies:

cut and count, kinematical fits and a few NNs.

Please let me know if anyone needs a tailored yaml file for his own validation!

(All I need to know is the VLQ mass, the branching ratio, and/or the representation of the VLQ)