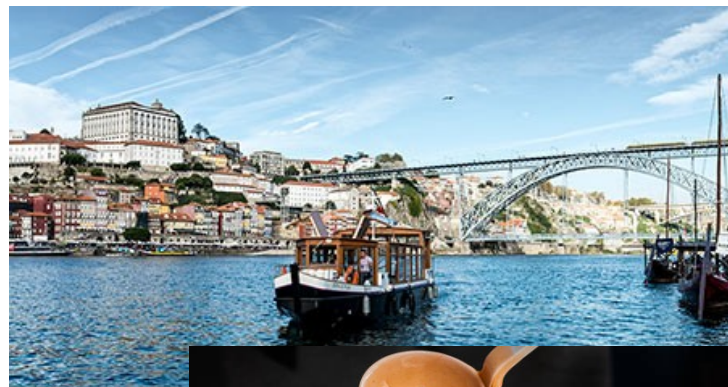# Extending the SMEFT

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Born in Porto

PhD in Granada

Now in Hamburg

A lot to discover...

Hobbies: food, sports, chess, board games, series

My work on effective field theories

$\Lambda \gg p$

UV physics

**EFT
Accessible scale**

p

Bottom up: Write observables in terms of Wilson coeff; Global fits, etc with <u>no mention of the UV</u>

My work on effective field theories

$\Lambda \gg p$

p

Top down: Calculate Wilson coeff from a particular UV scenario, building the <u>UV/IR Dictionary</u>

The SMEFT

Expansion into higher dimensional operators:

$$\mathcal{L}_{\mathrm{SMEFT}} = \mathcal{L}_{\mathrm{SM}} + \frac{\mathcal{L}_5}{\Lambda} + \frac{\mathcal{L}_6}{\Lambda^2} + \mathcal{O}(1/\Lambda^4)$$

$$\mathcal{L}_d = c_i \mathcal{O}_i$$
$$[\mathcal{O}_i] = d$$

Weinberg PRL43(1979)1566
Grzadkowski et al 1008.4884
Alonso, Jenkins, Manohar, Trott
1308.2627,1310.4838,1312.2014
Grojean, Jenkins, Manohar, Trott 1301.2588
Alonso, Chang, Jenkins, Manohar, Shotwell 1405.0486

Remmen and Rodd 1908.09845
Hays, Martin, Sanz, Setford, 1808.00442
Li, Ren, Shu, Xiao, Yu, Zheng 2005.00008
Murphy 2005.00059

The SMEFT at NLO

$$\mathcal{L}_d = c_i \mathcal{O}_i$$
$$[\mathcal{O}_i] = d$$

$$\mathcal{L}_{\text{SMEFT}} = \mathcal{L}_{\text{SM+s}} + \frac{\mathcal{L}_{5+s}}{\Lambda} + \frac{\mathcal{L}_6}{\Lambda^2} + \mathcal{O}(1/\Lambda^4)$$

SMEFT+ALP up to dimension-5

One-loop matching (g-2)

SMEFT at dimension-8

2012.09017

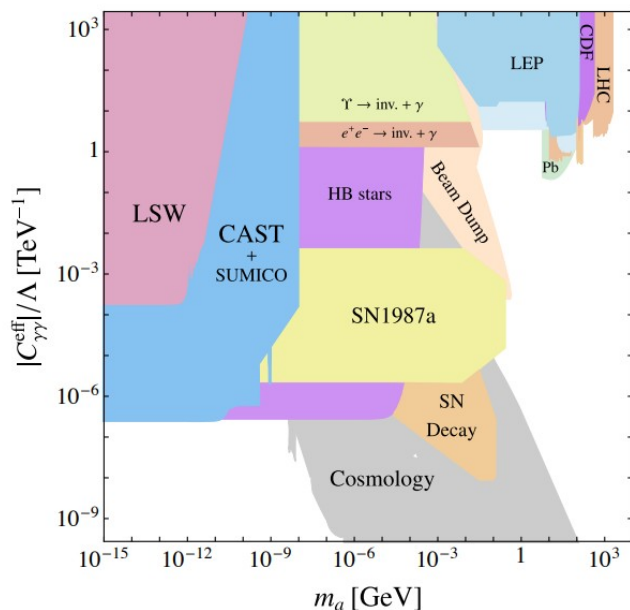M. Chala, G.G., M. Ramos, J. Santiago

2205.04480

G.G, P. Olgoso

2106.05291, 2112.12724, 2205.03301

S. Das Bakshi, M. Chala, A. Diaz-Carmona, G.G., M. Ramos, J. Santiago

The SMEFT+ALP

M. Bauer, M. Neubert, A. Thamm 2017

- Wide theoretical motivation for axion-like particles, such as pNGBs of new symmetries, the QCD axion, etc.

- Wilson coefficients **run**, and **mix**, following the corresponding renormalization group equations

> **Extension of basis with shift-symmetric operators**
> **&**
> **Derivation of bounds from mixing, much stronger than direct searches**

The SMEFT at dim8

No non-renormalization results
for mixed dimension

$$16\pi^2\mu\frac{dc_i^{(8)}}{d\mu} = \gamma_{ij}c_j^{(8)} + \gamma'_{ijk}c_j^{(6)}c_k^{(6)}$$

- Observables can get their leading contribution at this order; if the corresponding Wilson coeff is one-loop generated, **RGE can be leading effect**.

- Considered **tree-level generated WCs** (dim6 & dim8) which can renormalize the **bosonic** dim8 sector.

- Built the bosonic **Green's basis at dimension-8.**

> **Importance of one-loop effects to translate positivity bounds**
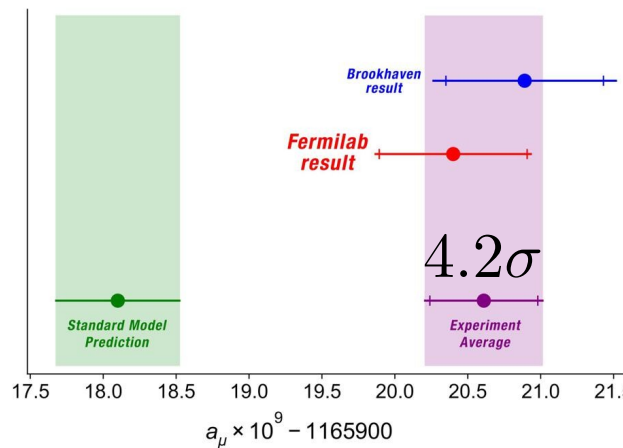>
> **Relevant phenomenological implications**

One-loop matching
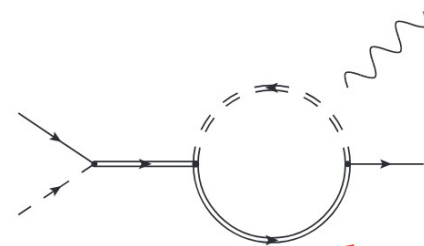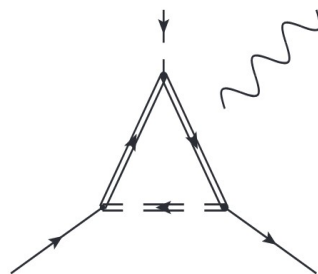
N. Arkani-Hamed and K. Harigaya, 2106.01373

L. Rose, B. Harling and A. Pomarol, 2201.10572

Big effort to explain this discrepancy in **SM extensions.**

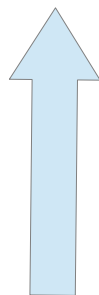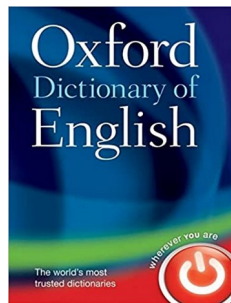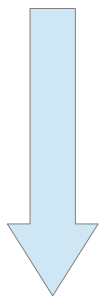$$\mathcal{O}_{eB} = (\bar{\ell}\sigma^{\mu\nu}e)HB_{\mu\nu} + \text{h.c.},$$
$$\mathcal{O}_{eW} = (\bar{\ell}\sigma^{\mu\nu}e)\sigma^I HW^I_{\mu\nu} + \text{h.c.}.$$

4.2σ

$a_\mu \times 10^9 - 1165900$

Found classes of 2- and 3-field extensions previously ignored in the literature

One-loop matching – IR/UV dictionary

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

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

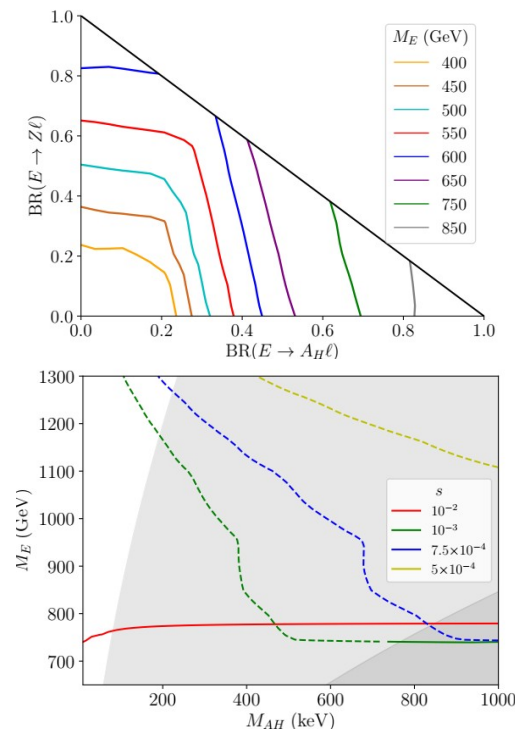- **Mathematica package – Smeft One-Loop Dictionary.**

2303.16965

G.G, P. Olgoso, J. Santiago

Collider and dark matter pheno

- Dedicated search for **vector-like leptons** with an exotic decay channel, *motivated by non-minimal composite scenarios*

- Current and future colliders

- Complementarity with DM when extra exotic particle is cosmologically stable
  - **Freeze-out** with co-annihilation
  - **Freeze-in**

Thanks

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