Putting SMEFT Fits to Work

Global Fits and the “Higgs Inverse Problem”

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A Number of Global Fits in the Literature…

Important to remember that ultimately we’re looking for *new physics!*

How do we interpret these limits in the context of particular models?
Strategy:

Integrate out new particles at matching scale (M ~ few TeV)

\[ \mathcal{L} \supset \lambda_3 \tilde{Q}_L \tilde{H} T_R \]

Generate subset of SMEFT Coefficients

\( (C_{Hq}^{(1)})_{33}, (C_{Hq}^{(3)})_{33}, C_t H, C_{HG} \)

Evolve Coefficients down to EW scale

\( C_{HD}, C_{H\square} \ldots \)

Fit to Higgs + Diboson + EWPO Data

Limits on physical parameters!

Example: \( T \) Vector-like Quark

\[ C_{HD}, C_{H\square} \ldots \]
SM + VLQ Singletlet Mixing with Top

Generates $C_{tH}$, $(C_{Hq}^{(1)})_{33}$, $(C_{Hq}^{(3)})_{33}$, $C_{HG}$ at the matching scale

**EWPO Constraints:**

$L_{1}$H Constraints:

**LHC Constraints:**

$$\Lambda = 1 \text{ TeV}$$

$$\left( C_{Hq}^{(1)} \right)_{33} = - \left( C_{Hq}^{(3)} \right)_{33} = \frac{1}{2Y_{t}}C_{tH}$$

Note: NLO effects important for these diboson limits! (1909.11576)

LEP sensitivity via $Z$ to $bb$ — flat direction broken by RGEs

Strong constraint from RGE induced operators
SM + VLQ Singlet Mixing with Top

Generates $C_{tH}$, $(C_{Hq}^{(1)})_{33}$, $(C_{Hq}^{(3)})_{33}$, $C_{HG}$ at the matching scale.

The T VLQ is a 1-parameter model — sweeps out only a line in this plane.

$$(C_{Hq}^{(1)})_{33} = -(C_{Hq}^{(3)})_{33} = \frac{1}{2Y_t} C_{tH}$$

$\Lambda = 1 \text{ TeV}$

Parameters generated by the model.

EWPO (RGE)  
Higgs + Diboson (RGE)  
Combined
SM + VLQ Singlet Mixing with Top

Generates $C_{tH}$, $(C_{Hq}^{(1)})_{33}$, $(C_{Hq}^{(3)})_{33}$, $C_{HG}$ at the matching scale
SM + VLQ Doublet Mixing with (t,b)

Generates $C_{bH}, C_{tH}, C_{Hb}, C_{Ht}, C_{Htb}, C_{HG}$ at the matching scale

EWPO Constraints:

\[ C_{bH} = C_{tH} = C_{Hb} = C_{Ht} = C_{Htb} = 0, \Lambda = 1 \text{ TeV} \]

LEP sensitivity via $Z$ to $bb$ — flat direction broken by RGEs

LHC Constraints:

- Strong constraint from RGE induced operators

EWPO (RGE) vs. EWPO

$C_{ht}/(1 \text{ TeV})^2$ vs. $C_{Ht}/(1 \text{ TeV})^2$
SM + VLQ Doublet Mixing with (t,b)

Generates $C_{bH}, C_{tH}, C_{Hb}, C_{Ht}, C_{Htb}, C_{HG}$ at the matching scale

Model described by two parameters — mixing angle and mass splitting

\[ C_{tH} = -Y_t C_{Ht}, \quad C_{bH} = Y_b C_{Hb}, \quad C_{HG} = \frac{\alpha_s}{8\pi} 0.65 C_{Hb} \]

\( \Lambda = 1 \text{ TeV} \)
SM + VLQ Doublet Mixing with (t,b)

Generates $C_{bH}, C_{tH}, C_{Hb}, C_{Ht}, C_{Htb}, C_{HG}$ at the matching scale

Model described by two parameters — mixing angle and mass splitting
SM + Singlet Scalar

Generates $C_H$, $C_{H\square}$ at the matching scale

$O_H = (H^\dagger H)^3$

Limits on the singlet from EWPO and LHC competitive — but most allowed coefficients cannot be generated in the model
Two Higgs Doublet Models

Generates $C_H$, $C_{bH}$, $C_{tH}$, $C_{\tau H}$ at the matching scale

2HDM limits come entirely from Higgs data
Different types of models sweep out wide range of allowed coefficients
Two Higgs Doublet Models

Generates $C_H, C_{bH}, C_{tH}, C_{\tau H}$ at the matching scale

Note that these are SMEFT Fits — not 2HDM fits!

Bounds can be reinterpreted in the usual physical parameter space
RGE effects slightly change the limits
Key Takeaways:

- RG Evolution is crucial in interpreting coefficients in terms of models!
- Also important to keep flavor assumptions in mind (1911.07866)

Lots more work to do:

- More robust understanding what coefficients can be generated
- Understand linear vs. quadratic approximation in fits in context of models?
- Include complete one-loop matching, more NLO effects in fits, and more distributions
- Top data is important for many of our models too, and should be included in global fits