intro to the EF discussion of global EFT fitting

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EF Restart Meeting
August, 2021

The EF04 organizers image this parallel session as a community discussion on issues in global EFT fitting. There will be talks about this topic in the Thursday 10am parallel session F. (“Eat desert first.”)

To organize the discussion, we thought to divide it into three parts, 30 minutes each.

We begin with the questions that are most straightforward to answer and advance to the more difficult ones.

Today, the Standard Model seems to describe all data from particle physics. The major challenge of particle experimentation is to “stress-test” the SM or prove that it is insufficient.

An important tool in this study is the combination of SM data into global fits. A particularly attractive formalism is that of the Standard Model Effective Field Theory (SMEFT). In this formalism, the SM is represented by the most general set of dimension 4 operators, and new physics appears as operators of higher dimension.

This formalism explains that BSM effects are small because new particles are heavy. Maybe we can show that dim-6 coefficients, e.g., are nonzero. Maybe we can show that they have a pattern that reveals the new theory underneath.

There are many questions to ask about the global SMEFT fit:

Do we need a more general EFT than SMEFT?

Can we separate “heavy” from “light”? Can light new physics particles be described in this framework? Does it make sense to truncate the expansion at dimension 6? Does “energy help accuracy” or can we fool ourselves?

What accuracy do we need in new physics contributions? Tree-level? NLO? What about QCD corrections?

How do we treat backgrounds, selections, systematic errors?

A very basic, troubling, question is that SMEFT or EFT fitting opens us to consider a very large number of parameters:

SMEFT dimension 6 ($\Delta B = 0$):
76 (1 gen.) or 2499 (3 gen.)

However well-formed are the numbers that go in, how do we control the fit to keep the numbers that come out from being meaningless?

We propose to discuss all of the questions in stages

1. the world of future e+e- colliders
   (moderator: Michael Peskin)

2. the world of hadron colliders, including the LHC
   (moderator: Christophe Grojean)

3. the world with the top quark mass and 3rd generation influence
   (moderator: Eleni Vryonidou)

At each stage, the questions get harder and more technical.

My segment, the e+e- world, is fairly simple.

There are only 7 dimension-6 B- and CP-conserving operators that contain W, Z, γ, Higgs only.

The ILC SMEFT fit tries to get away with 23 parameters

4 SM + 7 + 3 electron-Higgs couplings + 5 Higgs mods.
+ 2 EW combinations + 2 exotic Higgs decays

and there are plenty of observables (including w. beam polarization) to fix these.

Many effects are ignored (e.g. dimension 8, electroweak corrections). Are any essential? How can we do better?

for reference: 23 parameters for the ILC SMEFT fit:

$$\Delta\mathcal{L} = \frac{c_H}{2v^2}\partial^\mu(\Phi^\dagger\Phi)\partial_\mu(\Phi^\dagger\Phi) + \frac{c_T}{2v^2}(\Phi^\dagger \overleftrightarrow{D}^\mu\Phi)(\Phi^\dagger \overleftrightarrow{D}_\mu \Phi)$$

Higgs Z factor and T

$$-\frac{c_6\lambda}{v^2}(\Phi^\dagger\Phi)^3$$

triple Higgs

$$+\frac{g^2 c_{WW}}{m_W^2}\Phi^\dagger\Phi W^a_{\mu\nu}W^{a\mu\nu} + \frac{4gg' c_{WB}}{m_W^2}\Phi^\dagger t^a\Phi W^a_{\mu\nu}B^{\mu\nu}$$

$$+\frac{g'^2 c_{BB}}{m_W^2}\Phi^\dagger\Phi B_{\mu\nu}B^{\mu\nu} + \frac{g^3 c_{3W}}{m_W^2}\epsilon_{abc}W^a_{\mu\nu}W^{b\nu}{}_\rho W^{c\rho\mu}$$

h + W,Z,γ

$$+i\frac{c_{HL}}{v^2}(\Phi^\dagger \overleftrightarrow{D}^\mu\Phi)(\overline{L}\gamma_\mu L) + 4i\frac{c'_{HL}}{v^2}(\Phi^\dagger t^a \overleftrightarrow{D}^\mu\Phi)(\overline{L}\gamma_\mu t^a L)$$

$$+i\frac{c_{HE}}{v^2}(\Phi^\dagger \overleftrightarrow{D}^\mu\Phi)(\overline{e}\gamma_\mu e) \ .$$

Precision EW

$$-\sum_i\left\{c_{\ell i\Phi}\frac{y_\tau \ell i}{v^2}(\Phi^\dagger\Phi)\overline{L}_i\cdot\Phi\,\ell_{iR} + c_{qi\Phi}\frac{y_\tau qi}{v^2}(\Phi^\dagger\Phi)\overline{Q}_i\cdot\Phi\,q_{iR}\right\}$$

h→bb,cc, ττ,μμ

$$+\mathcal{A}\frac{h}{v}G_{\mu\nu}G^{\mu\nu} \ .$$

h→gg

need 2 more combinations of cHQ’s to close the fit;
2 more parameters for exotic and unclassified Higgs decays