Future Projects and Activities

Area 5 (UV Benchmark Models)

The University Of Sheffield.

Kristin Lohwasser
University of Sheffield

On behalf of the LHC EFT WG – Area 5 (UV Benchmark Models)

What we set out to do

> **Shopping list from 2nd general meeting (May 2021)**
  - https://indico.cern.ch/event/1016713/contributions/4310679/attachments/2234544/3787074/Area5-proposals.pdf
  - **1 One Loop accuracy matching**
  - **2 MSSM to SMEFT decoupling limit**

> **1 Matching**
  - Put together note based on Area 5 meetings:
    "Precision matching of microscopic physics to the Standard Model Effective Field Theory (SMEFT)"
  - Review of available matching (and related) codes
  - The document is on CDS and the arxive:
    https://cds.cern.ch/record/2842082

Area 5: Benchmark scenarios from UV models

Conveners: Admir Greljo, Kristin Lohwasser, Sally Dawson

Newly incoming: Shankha Banerjee, Sandra Kortner

1 Matching BSM to SMEFT at one loop accuracy

The standard model effective field theory (SMEFT) describes physics at energies below the new mass scale beyond the electroweak scale. The imprints of ultraviolet (UV) physics are encoded in the Wilson coefficients (WC) of the SMEFT. Measuring these coefficients and their correlations allows for discriminating between different UV models. The important technical step in this procedure is the *matching*, where the heavy degrees of freedom are integrated out and their effects are represented by local operators. The resulting WC are expressed in terms of the parameters of the UV theory such as couplings and masses. This facilitates the interpretation of the SMEFT analyses in explicit UV models.

Matching beyond tree-level is important since many interesting observables are generated only at the one-loop level. This task is not only technically challenging, but given the number of possible UV models, repetitive and time-consuming. To address the issue, several dedicated tools have been developed recently. For example, the `SuperTracer` [1] and `STrEAM` [2] packages aim at facilitating the one-loop EFT matching of generic UV models using the path integral methods. `Matchmaker` [3], instead, will automate the diagrammatic EFT matching of generic UV models (not yet released).

One of the goals of the Area 5 meetings is to come up with proposals for *benchmark models* which *i*) serve as a playground for validation of different tools for the automated matching and *ii*) are phenomenologically relevant. We envisage a set of standard benchmarks to be agreed among experts that will represent a challenge for these tools. Very few fully worked out benchmark examples exist in the literature, although, see for instance [4].

What is left to do (1)

> One-loop matching

- Plan to benchmark the described Matching Codes
  https://gitlab.com/modelmatch/ModelMatch / https://twiki.cern.ch/twiki/bin/view/LHCPhysics/EFTAC5

- **Open benchmarking exercise** using a gitlab repository / mirroed by twiki
  → Archive for BSM to SMEFT (and possibly other EFTs down the line) matching calculations
  → Will provide framework for comparison among different implementations

- **Archive will contain:**
  → Matching results: in any format that the authors deem appropriate
  → Validation: WCxf file with numerical matching coefficients for benchmark
  → Additional information: description *(author(s), theory assumptions including renormalization scheme, γ_5 prescription, gauge-fixing procedure, metric signature, and Levi-Civita convention)*.
  → Complete UV Lagrangian *(additional Lagrangian in the broken phase for heavy vectors)*
  → Set of benchmark parameter values used in the validation file

To do: Organise kick-off / discussion meeting between code authors to help get this activity started

What is left to do (2)

> MSSM to SMEFT decoupling limit

- Complementary to current limits from the experiments
- Suggested as activity but never fully explored / followed up (lack of person power)
- Given lack of SUSY signals possibly interesting for the experiments (extend phase space / make limits more general)

Area 5: Benchmark scenarios from UV models

Conveners: Admir Greljo, Kristin Lohwasser, Sally Dawson

Newly incoming: Shankha Banerjee, Sandra Kortner

2 MSSM to SMEFT decoupling limit

It is interesting to match the SMEFT to the MSSM to compare with the vast number of MSSM studies. The use of the SMEFT requires that the MSSM particles are much heavier than the weak scale. The one-loop WIlson coefficients found from integrating out MSSM stops can be found in [6] and global fits have been used to place restrictions on relatively light stops [7]. Alternatively, neutralinos and charginos can be taken heavy, integrated out and matched to the SMEFT [8]. Since the Higgs sector of the MSSM is the same as the type-II 2HDM, benchmarks from the 2HDM can be used to study the MSSM [5, 9].

Fitting to the whole set of coefficients generated by the MSSM requires choosing some initial benchmark points. One goal of the EFT-WG Area-5 is to develop a small set of benchmark points for comparison between MSSM studies and SMEFT studies and suggestions for such benchmarks are encouraged.

To do: Organise kick-off / discussion meeting to attact interested person power → identify interesting benchmark points / start matching

New ideas / projects

- **Similar to MSSM matching**
  - Provide matching specialised to models currently used for resonance searches such that SMEFT fits can be directly mapped to the same parameter space
  - Make a selection of the benchmarks (2HDM, HVT, Randall-Sundrum, scalar singlet, Z', leptoquarks….) -
  - Goal is to have things in a state that can be **readily** used by experiments in analysis (Providing the matching code and/or some Mathematica translation tables is probably be enough)
  - Could link into area 4 (Combined ATLAS/CMS fit → to include also benchmark models)
- **"Repository" to look up matchings / e.g. contact to authors ("phonebook") / beware of conventions!**
  - Again help for experimentalists (complementary to code benchmarking)

To do: Organise kick-off / discussion meeting to attact interested person power → identify interesting benchmark points / start matching
Need: experimentalists + theorists

Conclusions – where to go next

> Will of course continue to also organise meetings just to present / discuss papers relevant to Area 5

> Hoping for a fruitful discussion

> Did we overlook anything?

> Any further ideas?

Backup slides.