Report on Activities

Area 5 (UV Benchmark Models)

Kristin Lohwasser
University of Sheffield

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

Activities

> **Organised a number of meetings in the usual Indico category with 2 main topics**
  - https://indico.cern.ch/category/12671/
  - **Talks on UV benchmark models and their relation to EFT (including Leptoquarks, Heavy Vector Triplets, VBS benchmarks)**
  - **Presentations of general and public codes used to match UV to EFT**

> **Activities culminated in a note summarizing the public matching codes**
  - "Precision matching of microscopic physics to the Standard Model Effective Field Theory (SMEFT)"
  - The document is on CDS: https://cds.cern.ch/record/2842082 and will be uploaded to the arxive

Note

> **19 authors**
> **23 pages**

> **Overview over :**

- Matching Code
- Supplementary numerical codes
- Codes to (semi-)automatically match a concrete UV model to the SMEFT

  overview of the different codes and their primary functions

CERN-LHCEFTWG-20xx-yyy
CERN-LPCC-20xx-zz

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LHC EFT WG Note:
Precision matching of microscopic physics to the SMEFT

Sally Dawson[1,16], *Admir Greljo*[2,15,16], *Kristin Lohwasser*[3,16], *Jason Aebischer*[4], *Supratim Das Bakshi*[5], *Adrián Carmona*[5], *Joydeep Chakrabortty*[6], *Timothy Cohen*[7], *Juan Carlos Criado*[8], *Javier Fuentes-Martín*[5], *Achilleas Lazopoulos*[9], *Xiaochuan Lu*[7], *Pablo Olgoso*[5], *Sunando Kumar Patra*[10], *José Santiago*[5], *Anders Eller Thomsen*[2], *Zhengkang Zhang*[11], *Stefano Di Noi*[12,13], *Luca Silvestrini*[14]

[1] Department of Physics, Brookhaven National Laboratory, Upton, NY, United States
[2] Albert Einstein Center for Fundamental Physics, Institute for Theoretical Physics, University of Bern, Bern, Switzerland
[3] Department of Physics and Astronomy, University of Sheffield, Sheffield, United Kingdom
[4] Physik-Institut, Universität Zürich, Zürich, Switzerland
[5] Departmento Fisica Teorica y del Cosmos, Universidad de Granada, Granada, Spain
[6] Department of Physics, Indian Institute of Technology, Kanpur, 208016, India
[7] Institute for Fundamental Science, University of Oregon, Eugene, OR, United States
[8] Department of Physics, Durham University, Durham, United Kingdom
[9] Institute for Theoretical Physics, ETH Zürich, Zürich, Switzerland
[10] Bangabasi Evening College, Kolkata, India
[11] Department of Physics, University of California, Santa Barbara, CA, United States
[12] Dipartimento di Fisica e Astronomia "G. Galilei", Università degli Studi di Padova, Padua, Italy
[13] Istituto Nazionale di Fisica Nucleare, Sezione di Padova, Padua, Italy
[14] Istituto Nazionale di Fisica Nucleare, Sezione di Roma, Rome, Italy
[15] Department of Physics, University of Basel, Klingelbergstrasse 82, CH-4056 Basel, Switzerland
[16] Convenors of the LHC EFT working group area 5

Abstract
This note gives an overview of the tools for the precision matching of ultraviolet theories to the Standard Model effective field theory (SMEFT) at the tree level and one loop. Several semi- and fully automated codes are presented, as well as some supplementary codes for the basis conversion and the subsequent running and matching at low energies. A suggestion to collect information for cross-validations of current and future codes is made.

Keywords
EFT, One-Loop Matching, Running, UV models

The University Of Sheffield.

Content

General overview over how the codes work
+ suggestion of how to benchmark them

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

- **Should include comparison of capabilities and assumptions**

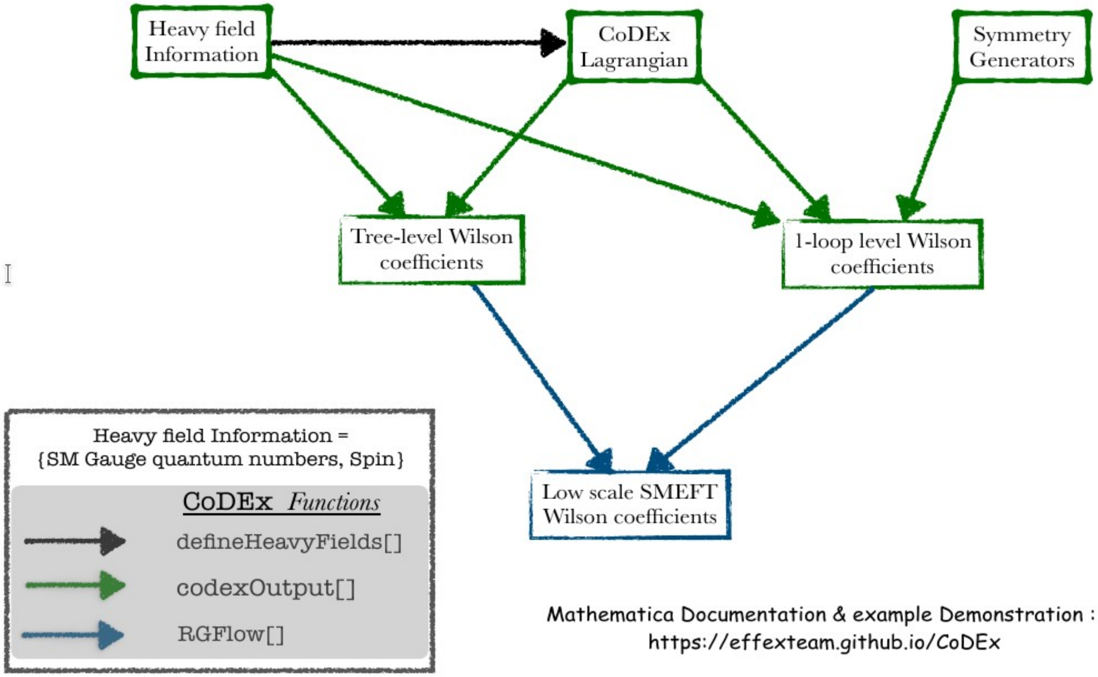
CoDEx

> **Mathematica** package to integrate out heavy fields of spin-0, 1/2, 1

> Computes the effective operators up to mass dimension-6 and associated Wilson coefficients

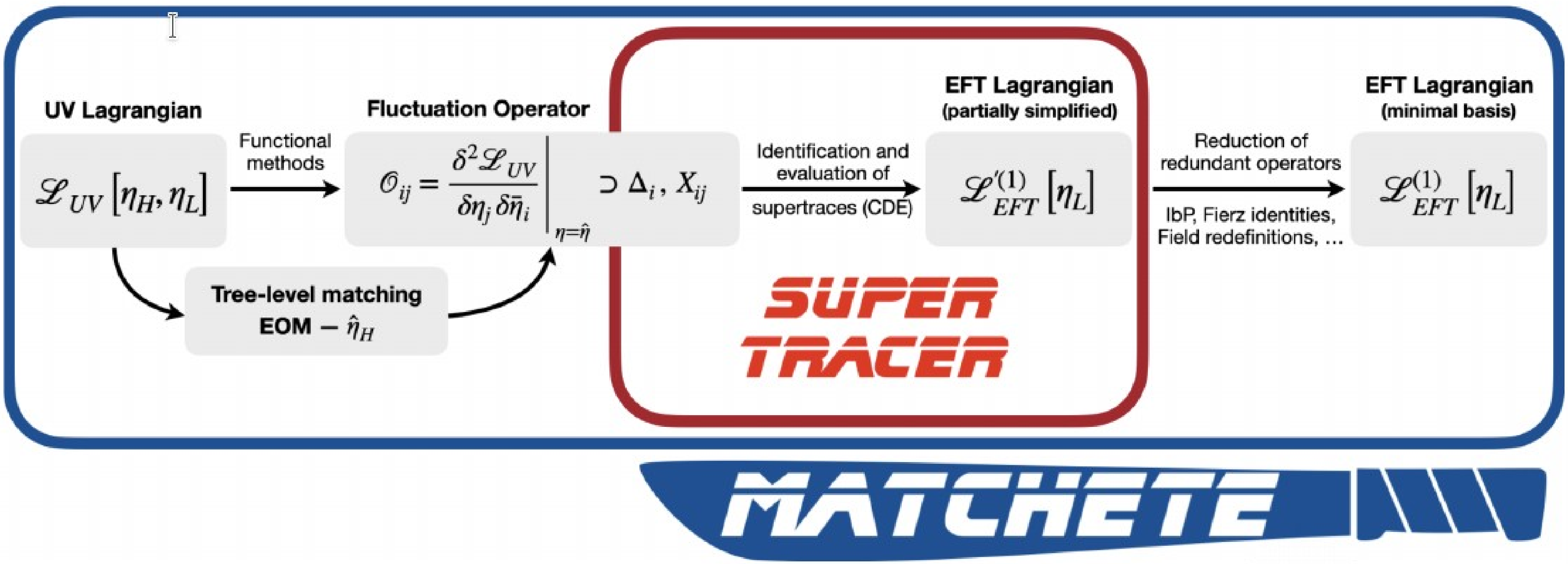
> Integration at tree- and 1-loop-levels with operators in both SILH and Warsaw bases

> Available on github: **https://effexteam.github.io/CoDEx/**



Matchete and SuperTracer

- **Mathematica** package: Automated complete one-loop matching of arbitrary UV models into their EFTs using a functional-matching procedure [arXiv:2012.08506].
- Matchete is to supersede SuperTracer as a fully automated matching tool, with a user-friendly interface that will only require the UV Lagrangian as user input.
- Available on github: **https://gitlab.com/supertracer/supertracer** and here: **https://gitlab.com/matchete/matchete** (preliminary version)



Matchmakereft

- **Python** tool to perform the matching of *arbitrary models* onto *arbitrary effective* theories up to one-loop order in an automated way.

- Diagrammatic fashion: matching one-light-particle-irreducible (1LPI) off-shell amplitudes functions in the background field method. Dimensional regularization in MSbar scheme and anti-commuting γ_5 convention (enough for most SMEFT applications).

- **Further information:**

  - project web page: **https://ftae.ugr.es/matchmakereft/**

  - Manual: Matchmakereft: automated tree-level and one-loop matching, **arXiv:2112.10787**.

  - Code: **https://gitlab.com/m4103/matchmaker-eft**
    (Install via pip)

MatchingTools

- **Python** package for performing tree-level matching calculations between general EFTs, and for implementing the algebraic manipulations of effective Lagrangians

- Code is publicly available at **github.com/jccriado/matchingtools**

- Additional tool for
  - definition of tensors and rules relevant for SU (2), SU (3) and Lorentz group theory
  - definitions of the SM fields
  - rules for applying the SM equations of motion

- **Further information:**

  - **matchingtools.readthedocs.io.**

STrEAM

- **S**uper**Tr**ace **E**valuation **A**utomated for **M**atching
- **Mathematica** package that automates the evaluation of functional supertraces that could arise when one matches a generic UV theory onto a relativistic EFT.
- Could provide the result to arbitrary order in the heavy mass expansion
- Code is publicly available at **https://www.github.com/EFTMatching/STrEAM**

Additional tools

- > **DsixTools** is an open-source Mathematica package that automates one-loop RGE in the SMEFT and in the LEFT], as well as one-loop SMEFT-to-LEFT matching

- > **DRGESolver** is an open-source C++ library that performs the renormalization group evolution of the SMEFT Wilson coefficients in a fast and easy-to-use manner. The library deals with the most generic flavor scenario, assuming only lepton and baryon number conservation.

- > The **Wilson coefficient exchange format (WCxf)** defines a standard for Wilson coefficients used in computer codes. Since many different conventions are being used in the literature, it is important to have a collection of unique definitions for the different bases and the corresponding Wilson coefficients, especially when comparisons between different codes are performed.

- > The Python package **wilson** is a matchrunning tool. It allows to numerically run all Wilson coefficients in the SMEFT to arbitrary scales, as well as matching them onto the LEFT. Furthermore, the full LEFT running below the electroweak scale is implemented in wilson.

Conclusions

> Note is on CDS https://cds.cern.ch/record/2842082

> Comments still open

> Future projects to be discussed this afternoon

Backup slides.

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