Scientific Unit of Excellence High Energy Theory (FTAE)

Review by International Advisory Committee
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Particle Theory I

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FTAE High Energy Theory

Who we are

Unified project from the merging of two coordinated ones:

PID2022-139466NB-C21
Phenomenological Implications of Physics Beyond the Standard Model

José Santiago (PI1)
Adrián Carmona (PI2)
Jorge de Blas
Javier Fuentes Martín
Roberto Vega Morales

PID2022-139466NB-C22
Formal developments and new techniques in quantum field theory

Manuel Pérez-Victoria (PI1)
Roberto Pittau (PI2)
Mikael Chala
Fernando Cornet
Juan Carlos Criado

Who we are

Unified project from the merging of two coordinated ones:

PID2025-170216NB-I00
Physics Beyond the Standard Model: Formal and Applied Developments

José Santiago (PI1)
Juan Carlos Criado (PI2)
Jorge de Blas
Adrián Carmona
Javier Fuentes Martín
Manuel Pérez-Victoria
Roberto Vega Morales

Research

GO1: Formal and applied developments in EFTs
- SO1: Formal developments in EFTs
- SO2: Applied developments in EFTs

GO2: Direct and indirect signatures of new physics at colliders and beyond

GO3: Formal aspects of QFT

SMEFT and HEFT are the standard tools to systematically study BSM

Dictionaries

"Granada dictionary" (tree, dim-6)

SOLD (1-loop, dim-6)

Formal developments

Automated tools

Matchmaker

MatchingTools

MATCHETE

Sym2Int

mosca

BasisGen

Dsix Tools

HEPfit

MATCHETE

Research

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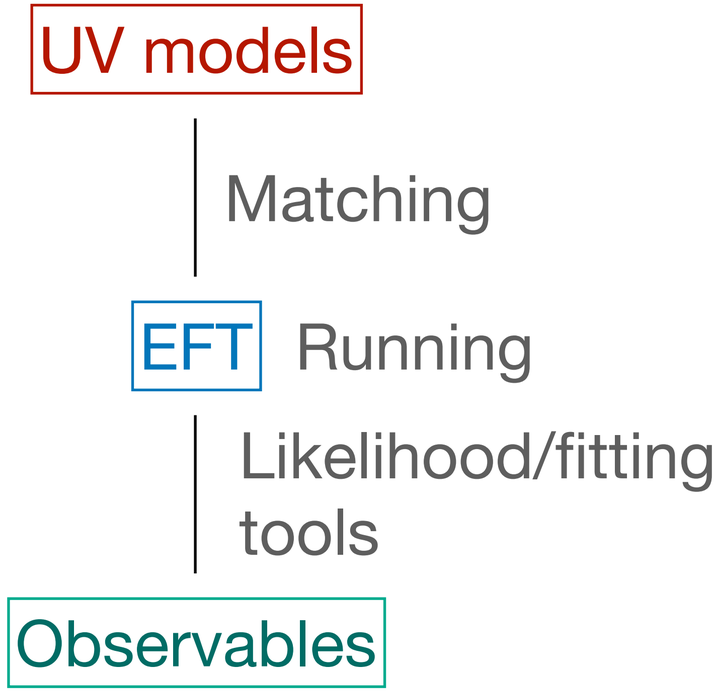
GO2: Direct and indirect signatures of new physics at colliders and beyond

GO3: Formal aspects of QFT



General developments and automation

1-loop matching with vectors

2-loop running/matching

Calculation of observables to higher orders (1-loop, dim-8, …)

Interfaces between tools

On-shell matching

3D EFTs for cosmological phase transitions

SMEFT dictionaries

1-loop for vectors, higher-spin, dim-8, …

Research

GO1: Formal and applied developments in EFTs

GO2: Direct and indirect signatures of new physics at colliders and beyond

- SO3: Global analyses of new physics using EFTs
- SO4: Study of phenomenological implications of new physics at colliders
- SO5: Dark matter model building and phenomenology
- SO6: Flavour physics

GO3: Formal aspects of QFT

Global EFT fits HEPfit

Required precision for current data

Relaxed flavour assumptions

Future colliders *European Strategy for Particle Physics*

New physics at colliders

Higgs: CP, anomalous couplings, extensions

Elusive models

DM model building

Inflationary mechanisms for DM production

Strongly-coupled DM

Flavor model building

Phenomenology of multi-brane models in extra dimensions

Research

GO1: Formal and applied developments in EFTs

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GO3: Formal aspects of QFT

- SO7: Aspects of QFT in curved space-time
- SO8: Non-perturbative effects
- SO9: Amplitude methods for non-standard states

Schwinger effect in curved spacetimes

EFT tools for **cosmological correlators**

Skyrmions (solitons) in the EW theory and beyond

Methods

Numerical algorithms for **resurgence**

Real-time lattice simulations with **quantum computing**

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GO3: Formal aspects of QFT

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- SO8: Non-perturbative effects
- SO9: Amplitude methods for non-standard states

Phenomena beyond the standard stable particles of spin ≤ 1

Unstable particles: on-shell methods, field redefinitions

Massive higher-spin particles: formalism

Continuous spin: on-shell vs Lagrangian formalism, phenomenology

Unparticle stuff: theoretical description, DM model building

Summary

- Active team with ample experience in EFTs, BSM pheno, formal QFT
- Since 2022: 80+ publications with 4000+ citations
- Contributions to many open-source codes for EFT calculations
- Training: 6 PhD theses defended in the last 10yrs, 7 currently under way
- Outreach: European Researchers' Night, Science Week, high-school talks…
- Ambitious project for advancing particle physics on multiple fronts