EPFL

PHYS-746 **Before and Behind the Standard Model**

Wulzer Andrea

Cursus	Sem.	Type
Physics		Obl.

Language of teaching	English
Credits	2
Session	
Exam	Oral
Workload	60h
Hours	**28**
Courses	28
Number of positions	

Frequency

Every 2 years

Remark

Every 2 years / Next time: Spring 2019

Summary

The course offers a conceptually and methodologically advanced overview of the Standard Model and of some of its extensions. It provides the students with the basic tools and with the first elements of â##Beyond the SMâ## model-building and phenomenology.

Content

Students will first learn advanced theoretical tools such as Effective Field Theories, the Stueckelberg approach to gauge invariance in connection with renormalizability, and the Equivalence Theorem. These tools will be applied to the theoretical and phenomenological study of illustrative Beyond-the-SM (BSM) scenarios.

Part 1: Before the SM:
This part is built around the concept of “No-Lose Theorems”, defined as absolute guarantees of discovering new phenomena under suitable experimental conditions. It is argued that the existence of these theorems is what made high energy physics play the leading role in fundamental research over the last half a century. Three No-Lose Theorems are presented, together with all the theoretical tools needed for their formulation and for drawing their implications. The detailed program reads:

- The general concept of an Effective Field Theory (EFT). Growing-with-energy couplings. (Non-)renormalizable EFT’s and the EFT cutoff. Power-counting(s). The Fermi theory example.
- The Fermi theory at one-loop. The maximal cutoff of the Fermi theory: perturbativity vs partial wave unitarity. Need for physics Beyond the Fermi Theory.
- Diboson production from bb scattering, perturbativity breakdown in the absence of the top quark. Need for physics Beyond the bottom quark.
- Why a gauge symmetry is never broken (and thus is not a symmetry): Stueckelberg trick and non-renormalizability of the bottom-only theory.
- The Goldstone Boson Equivalence Theorem: proof and examples. Anomalous growth of bb>WW from a “hidden” d=6 operator.
- Non-perturbativity in WW scattering and the need of new physics at the LHC.

Part 2: Behind the SM:
The first aim is to provide a concrete illustration of the special phenomenological properties of the SM that make is so suited to describe observations, and of how even seemingly mild SM extension may not possess these properties and enter in conflict with observations. The second one is to discuss two of the open problems of the SM, Naturalness and Dark Matter, explaining how and to what extent they can be solved in specific BSM scenarios. The tentative program is:

- Accidental Symmetries
- Extended Higgs sectors and accidental symmetries violation
- Electroweak Precision Tests and Technicolor
- Higgs couplings measurements and extra scalar singlets
- Composite Higgs and Naturalness
- Possible Dark Matter models

Note

Examination procedure: oral + exercices
Dates of the course: 19.02.19 to 27.04.19.

Keywords

Higgs Model, Beyond the Standard Model, Effective Field Theory, High-Energy Physics

Learning Prerequisites

Required courses

Basic knowledge of the Standard Model and of Quantum Field Theory is required

Expected student activities

Appreciate those aspects that make the Standard Higgs Model unique as a description of Electroweak interactions and of Electroweak symmetry breaking. Gain concepts and tools needed to design further experimental test of the Higgs model at the LHC and future colliders.