UCLouvain

lphys2131

2025

Fundamental interactions and elementary particles

The version you're consulting is not final. This course description may change. The final version will be published on 1st June.

10.00 credits	52.5 h + 7.5 h	Q1

Language :	English > French-friendly
Place of the course	Louvain-la-Neuve
Prerequisites	No prerequisites for students who have obtained a Bachelor's degree in physics and who therefore already have a basic knowledge of classical gravitation (G_N), relativistic mechanics (c),quantum mechanics (h) and, ideally, relativistic gravitation (G_N+ c).
Main themes	Introduction to the concept of unification based on gauge invariance and description of the sometimes surprising rules governing our universe both at the microscopic level (' 10^{-20} m) and at the macroscopic level (' 10^{+26} m), through the interactions of its content in matter and energy, namely: ordinary matter, antimatter, extraordinary matter, dark matter and dark energy. Introduction to the major experiments that led not only to the construction of the Standard Model but also to its validation and discussion of the difficulties encountered in their achievements
Learning outcomes	**At the end of this learning unit, the student is able to :** **a. Contribution of the teaching unit to the learning outcomes of the programme (PHYS2M and PHYS2M1)** AA1: A1.1, A1.4 AA3: A3.1 AA5: A5.3 AA7: A7.2 **b. Specific learning outcomes of the teaching unit** 1 At the end of this teaching unit, the student will be able to: 1. formulate the theoretical concepts associated with fundamental interactions (including gravitation) by highlighting a unifying principle, gauge invariance and a separating mechanism, symmetry breaking ; 2. present the great experiments at the base of the Standard Model describing the fundamental interactions (strong, weak and electromagnetic) between the elementary particles (quarks, leptons and bosons of gauges, Higgs boson) ; 3. integrate experimental and data analysis techniques used in modern experiments in particle physics.
Evaluation methods	• Oral exam on the whole teaching unit during the exam session. • Preparation of two questions of your choice (one in the theoretical part and another one in the more experimental part) to present orally (either during the examination or during presentation sessions that will eventually be scheduled at the end of the semester). • A "laboratory" report (on the observation of the W and Z bosons at the LHC) to be defended orally.
Teaching methods	Lectures (presentation on the blackboard and projection of transparencies). Integrative project. Practice sessions on analysis of LHC events.
Content	1) Theoretical and experimental introductions to fundamental interactions. Topics covered are - natural units - Maxwel electromagnetism to gauge invariant Lagrangian - the scalar fields and the Klein-Gordon equation - the fermionic fields and the Dirac equation - the electroweak interactions (beta decay, Fermi's theory, neutral currents) - parity violation - Electrweak symmetry breaking - fermion masses and mixing

	- Mésons and baryons - Partons - Strong interaction and color 2) Description of these processes in terms of observables such as cross sections and life time using simple Feynman diagrams. Discussion of these processes in terms of observables such as cross sections and life time and how they can be measured experimentally. Discussions of open questions in particle physics and how experiments can lead to new discoveries.
Bibliography	Modern Particle Physics, M. Thomson High Energy Physics, 4th Edition, D.H. Perkins. Brian R. Martin, Graham Shaw, "Nuclear and Particle Physics: An Introduction", 3rd Edition, ISBN: 978-1-119-34461-2.
Other infos	Following the sanitary conditions, the modalities of the teaching AND the examination could be reassessed according to the situation and the rules in force.
Faculty or entity in charge	PHYS

Programmes containing this learning unit (UE)

Program title	Acronym	Credits	Prerequisite	Learning outcomes
Master [60] in Physics	PHYS2M1	10		🔍
Master [120] in Physics	PHYS2M	10		🔍
Master [120] of Education, Section 4 : Physics	PHYS2M4	10		🔍