2EL1910 – Fundamental laws of the Universe: particle and gravitation physics

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Department: DÉPARTEMENT PHYSIQUE
Language of instruction: FRANCAIS
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 60
On-site hours (HPE): 35,00
Elective Category : Fundamental Sciences
Advanced level : No

Description
This course is an introduction to the four fundamental interactions: particle physics on the one hand and gravitational physics and cosmology on the other, from both theoretical and experimental points of view.

Quarter number
SG8

Prerequisites (in terms of CS courses)
None

Syllabus

A. Particle physics

A.1 Historical introduction to elementary particles
A.2 Special relativity and relativistic dynamics
A.3 Fundamental Interactions
A.4 Standard model of particle physics

B. Gravitation

B.1 General relativity: principle of equivalence, equation of motion, Einstein equation
B.2 Cosmology: geometry and expansion of the Universe, thermal history, structure formation (CMB), dark matter, dark energy
B.3 Example of an observational cosmology project: DESI, study of dark energy and gravitation, selection of quasars, tomography of the Universe with quasars

Class components (lecture, labs, etc.)
Nine one-and-a-half-hour lectures on particle physics and nine one-and-a-half-hour lectures on gravitation and cosmology. Six hours of TD for final exam preparation.

Grading
The evaluation will combine a final test [75% of the grade] and a continuous assessment [25% of the grade].

All skills will be assessed in both types of testing. But more specifically, C2-1 skills will be tested mainly in the final exam, while C1-2, C2-3 and C6-3 skills will be tested in the continuous assessment and during the guided work sessions.

Course support, bibliography
Videos, course slides, written materials and also bibliographical references distributed during the course.

Resources
The classes will be lectures that will end with exercises counting as continuous assessment. Slides and written material will be made available.

Learning outcomes covered on the course
- get familiar with concepts of elementary particle and fundamental symmetry
- master the concepts of spacetime and quadrivector
- identify the relevant inertial referentials in a problem and control Lorentz transformations.
- Understand the difference between conservation and invariance and how to apply energy-momentum conservation in space-time.
- master the basics of tensor algebra with Einstein's notations
- calculate relativistic corrections for the Global Positioning System

Description of the skills acquired at the end of the course
C1.2 - Know how to use a model presented in the lecture in a relevant way
C1.3 - Develop a numerical simulation
C2-1 - Deepen this knowledge in particle physics and cosmology
C6-3 - Process particle physics and astrophysics data -