



---

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

---

**Instructors:** Christophe Yèche, Samira Hassani

**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 -