Course Title : **Beyond the Standard Model**

Number of hours/semester : 30 h, 2nd Semester

Number of ECTS : 3

Lecture outline, contents :

The Standard Model of particle physics, despite its immense success, suffers from many practical limitations and conceptual problems, such as the problem of hierarchy or lack of candidate particle explaining the presence of dark matter in the universe. As a result, many theories beyond the Standard Model have been developed over the last few decades. In this course, we will study, from a theoretical, phenomenological and experimental point of view, some of the most important ideas in the light of current research in high energy physics.

The theoretical part of the course covers, after a quick review of the Standard Model, supersymmetry, composite models, grand unification theories as well as those with additional spatial dimensions. We will construct the minimal models in each of these cases from basic principles of quantum field theory, and we will review their main phenomenological consequences. We will also study black matter and the ways to look for it. Collider simulation techniques are also addressed.

The experimental part of the course is divided into three parts. First, experimental and analytical tools are introduced for physics research beyond the Standard Model. The second part covers direct research (supersymmetry, new quarks and bosons of gauges, ...). Finally, the third part covers indirect research via precision measurements (Higgs sector and flavor).

Pedagogical methods : Lectures and Tutorials

Prerequisites : Quantum field theory, relativistic quantum mechanics, Standard Model

Modalities of knowledge assessment : Oral examination at the end of the semester for the first session and oral examination for second session (for the second session, the maximum grade is limited to 10)

Bibliography :

1. B. Fuks, *Supersymmetry - When Theory Inspires Experimental Searches*, arXiv:1401.6277 [hep-ph] (chapters 1, 2, 4 and 5)
2. G. Panico and A. Wulzer, *The Composite Nambu-Goldstone Higgs*, Lect. Notes Phys. **913** (2016), pp.1-316, arXiv:1506.01961 [hep-ph].
3. M. Bauer and T. Plehn, *Yet Another Introduction to Dark Matter: The Particle Physics Approach*, Lect. Notes Phys. **959** (2019), arXiv:1705.01987 [hep-ph].