DI.201.HEP Extensions of the standard model of elementary particles (BSM)

1. Study program

1.1. University	University of Bucharest, West University of Timișoara,
1.2. Faculty	Faculty of Physics
1.3. Department	Department of Theoretical Physics, Mathematics, Optics, Plasma and Lasers
1.4. Field of study	Physics
1.5. Course of study	Master of Science
1.6. Study program	High Energy Physics (in English)
1.7. Study mode	Full-time study

2. Course unit

2.1. Course unit title	Extensions of the standard model of elementary particles (BSM)								
2.2. Teacher				Călin Alexa, Roxana Zus					
2.3. Tutorials/Practicals instructor(s)				Călin Alexa, Roxana Zus					
2.4. Year of study	II	2.5. Semester	1	2.6. Type of evaluation	E	2.7. Type of course unit	Content[1)]	DF
							Type[2)]	DI

[1)] fundamental (DF), specialized (DS); complementary (DC)
[2)] compulsory (DI), elective (DO), noncompulsory disciplines (DFC)

3. Total estimated time (hours/semester)

3.1. Hours per week in curriculum	**4**	distribution: Lecture	**2**	Practicals/Tutorials	**2**
3.2. Total hours per semester	**56**	Lecture	**28**	Practicals/Tutorials	**28**

Distribution of estimated time for study	**hours**
3.2.1. Learning by using one's own course notes, manuals, lecture notes, bibliography	**30**
3.2.2. Research in library, study of electronic resources, field research	**30**
3.2.3. Preparation for practicals/tutorials/projects/reports/homeworks	**32**
3.2.4. Preparation for exam	**4**
3.2.5. Other activities	**0**

3.3. Total hours of individual study	**96**
3.4. Total hours per semester	**150**
3.5. ECTS	**6**

4. Prerequisites (if necessary)

4.1. curriculum	Quantum mechanics, Electrodynamics, Theory of relativity, Nuclear physics
4.2. competences	Knowledge about: algebra, quantum mechanics, electrodynamics

5. Conditions/Infrastructure (if necessary)

5.1. for lecture	Video projector
5.2. for practicals/tutorials	

6. Specific competences acquired

Professional competences	• Identify and proper use of the main physical laws and principles in a given context: the use of the concepts of the standard model • Solving problems of physics under given conditions • Use of the physical principles and laws for solving theoretical or practical problems with qualified tutoring • Rigorous knowledge of quantum field theory, concepts, notions and problems in the area of theoretical particle physics and their interactions • Ability to use this knowledge in interpretation of experimental result and understand experiments at CERN; acquire the appropriate understanding of studied fundamental mechanisms
Transversal competences	• Efficient use of sources of information and communication resources and training assistance in a foreign language • Efficient and responsible implementation of professional tasks, with observance of the laws, ethics and deontology.

7. Course objectives

7.1. General objective	To provide a pedagogical introduction to supersymmetry. This course is intended to be an elementary and practical introduction to supersymmetry in particle physics providing an accessible, self-contained account of the basic concepts required for a working understanding of the 'Minimal Supersymmetric Standard Model' (MSSM).
7.2. Specific objectives	Specific objectives will include motivations for supersymmetry, the construction of supersymmetric Lagrangians, superspace and superfields, soft supersymmetry-breaking interactions, the Minimal Supersymmetric Standard Model (MSSM), R-parity and its consequences, the origins of supersymmetry breaking, the mass spectrum of the MSSM, decays of supersymmetric particles, experimental signals for supersymmetry, and some extensions of the minimal framework.

8. Contents

8.1. Lecture [chapters]	Teaching techniques	Observations/ hours
Introduction and motivation	Systematic exposition - lecture. Examples.	2 hours
Spinors: Weyl, Dirac and Majorana. Introduction to supersymmetry and the MSSM. The supersymmetry algebra and supermultiplets. The Wess–Zumino model.	Systematic exposition - lecture. Examples.	12 hours
Superfields. Vector supermultiplets. The MSSM. SUSY breaking. The Higgs sector and electroweak symmetry. Origins of supersymmetry breaking. Sparticle masses in the MSSM. Sparticle decays. Experimental signals for supersymmetry. Beyond the MSSM.	Systematic exposition - lecture. Examples.	14 hours

Bibliography:

1. Ian J.R. Aitchison, Supersymmetry in particle physics - an elementary introduction, Cambridge University Press, 2007
2. Stephen P. Martin, A Supersymmetry primer, 2016 https://inspirehep.net/literature/448462
3. Particle Data Group - The Review of Particle Physics (2024) https://pdg.lbl.gov/2024/

8.2. Tutorials [main themes]	Teaching and learning techniques	Observations/hours
Problems specific for each section of the course.	Problem solving.	14 hours
Event generators for high-energy particle collisions. Particles collisions.	Guided work.	14 hours

Bibliography:

1. Ian J.R. Aitchison, Supersymmetry in particle physics - an elementary introduction, Cambridge University Press, 2007
2. Stephen P. Martin, A Supersymmetry primer, 2016 https://inspirehep.net/literature/448462
3. PYTHIA 8, https://pythia.org/manuals/pythia8312/Welcome.html
4. MadGraph5_aMC@NLO, http://madgraph.phys.ucl.ac.be/
5. HEPForge, https://www.hepforge.org/

9. Compatibility of the course unit contents with the expectations of the representatives of epistemic communities, professional associations and employers (in the field of the study program)

This course unit develops some theoretical competences, which are fundamental for a Master student in the field of modern physics, corresponding to national and international standards. The contents is in line with the requirement of the main employers of research institutes and universities.

10. Assessment

Activity type	10.1. Assessment criteria	10.2. Assessment methods	10.3. Weight in final mark
10.4. Lecture	- coherence and clarity of exposition - correct use of equations/mathematical methods/physical models and theories - ability to indicate/analyse specific examples	Written test/oral examination	60%
10.5.1. Tutorials	- ability to use specific problem solving methods - ability to analyse the results	Homeworks/written tests	40%
10.6. Minimal requirements for passing the exam			
Attendance of at least 50% for the lectures and at least 70% for the tutorials. **Correct solutions to the indicated subjects for obtaining the grade 5 (10 points scale) from all activities, part of the continuous evaluation.** **Correct solutions to the indicated subjects for obtaining the grade 5 (10 points scale) within the final exam.**			

Date	Teacher's name and signature	Practicals/Tutorials instructor(s) name(s) and signature(s)
4.10.2024	Călin Alexa, Roxana Zus [redacted]	Călin Alexa, Roxana Zus [redacted]

Date of approval [redacted]

Head of Department
Lect.dr. Roxana Zus [redacted]