Anexa Nr. 2

Subject content

1. Program information

1.1. University	West University of Timişoara
1.2. Faculty	Physics
1.3. Departament	Physics
1.4. Study direction	Physics
1.5. Study cycle	Master
1.6. Study program*	**Astrophysics, Elementary Particles and Computational Physics** / conform COR: fizician (211101); profesor în învăţământul gimnazial (232201 - în condiţiile legii); asistent de cercetare (248102); referent de specialitate în învăţământ (235204); analist (213101; analist financiar (241493).

2. Subject matter information

2.1. Subject matter			Quantum fields (AP1204)				
2.2. Subject teacher			Victor E. AMBRUȘ				
2.3. Subject applications teacher			Victor E. AMBRUȘ				
2.4. Study year	II	2.5. Semester	I	2.6. Assesment type	**E**	2.7. Subject type	**DF / DO**

3. Study time distribution

3.1. Nr. of hours / week	3	In which: 3.2 course	2	3.3. Problem class	1
3.4. Total hours in educational plan	42	In which: 3.5 course	28	3.6. Problem class	14

Time distribution*	**hrs**
Study after lecture notes, bibliography or notes	28
Additional documentation in the library, electronic specialty platforms/ field	20
Seminar/ laboratory preparations, homework, portfolio and essays	28
Tutoring	16
Exams	16
Other activities....	

3.7. Total number of personal study hours	108
3.8. Total number of hours in semester	150
3.9. Number of credits	6

4. Preconditions

4.1. Curriculum	Complements of Theoretical Physics (AP1101); Complements of Atom and Molecule Physics (AP1103);
4.2. Skills	General skills: ability to assimilate fundamental knowledge; correct usage of physics-specific terminology; ability to work individually and as part of a team; Professional skills: the correct identification and usage of the main laws and principles of physics; ability to solve physics-specific problems.

5. Course objectives – expected results achieved by attending and graduating this course

Knowledge	The correct identification and usage of the main laws and principles of physics relevant to this course in a given context Relativistic description of quantum systems Many-body systems and second quantization Quantum thermodynamic ensembles
Abilities	Solving physics problems in given conditions, using analytical and numerical methods Understanding of fundamental concepts in high-energy particle physics (HEPP)
Responsability and autonomy	Acquaintance with modern directions related to Quantum Field Theory Understanding the fundamentals of high-energy particle physics Learning about modern particle physics experiments at CERN and RHIC

6. Table of contents

6.1. Course	Teaching methods	Observations
Chap.1. Introduction (2 hours)	Interactive lecturing at the blackboard or using the beamer.	
Chap.2. Relativistic quantum mechanics (10 hours) Representations of the Lorentz and Poincare groups. Noether's theorem. Conserved currents and charges. Klein-Gordon, Dirac and Proca equations. Electromagnetic coupling. Non-relativistic limit. Hydrogen-like atoms.		[1] Ch. 2. [2] Ch. 2. [3] Part I, Ch. 2.1, 2.2; Ch. 3.1-3.4. [4] Ch. 2,3,4. [5] Ch. 2. [6] Ch. 1.

Chap. 3. Second quantization (10 hours) General formulation. Normal ordering. Fock space. Scalar (Klein-Gordon) field. Spin ½ (Dirac) field. Vector (Maxwell-Proca) field. CPT transformations.		[1] Ch. 3 [2] Ch. 5 [3] Ch. 10.1, 10.2 [4] Ch. 2.3, 2.4; 3.4-3.6. [5] Ch. 3-7.
Chap. 4. Thermal field theory (6 hours) Mixed states. Thermodynamic equilibrium. The Kubo-Martin-Schwinger theorem. Thermal averages.		[6] Chap. 4.

Bibliography

1. C. Itzykson, J.-B. Zuber, Quantum field theory (Dover, 2005).
2. S. Weinberg, The Quantum Theory of Fields, (Cambridge Univ. Press, 1995).
3. B. Thaller, The Dirac Equation (Springer Verlag, 1992).
4. M. E. Peskin, D. V. Schroeder, An introduction to quantum field theory (CRC Press, 2019).
5. W. Greiner, J. Reinhardt, Field quantization (Springer-Verlag, 1996).
6. S. Mallik, S. Sarkar, Hadrons at finite temperature (Cambridge Univ. Press, 2016).

6.2. Seminar/laboratory	**Teaching methods**	**Observations**
Chap.1. Introduction (1 hour) Recapitulation	Problem solving at the blackboard and in the notebooks.	The bibliographic references follow those from the course.
Chap.2. Relativistic quantum mechanics (5 hours) Poincare algebra. Induced representations. Charge current. Energy-momentum tensor. Plane-wave solutions. Green’s functions. Landau levels in a constant magnetic field. Fine structure splitting.		
Chap. 3. Second quantization (5 hours) Conserved operators. Pseudo-gauge transformations. Coherent states. Helicity and chirality. Coulomb gauge. Casimir effect. CPT properties of the conserved operators.		
Chap. 4. Thermal field theory (3 hours) Relativistic statistical mechanics. Partition function. Finite-temperature Green’s functions. Vortical effects.		

Bibliography
See 6.1. Course.

7. Matching course contents with expectations of representatives of the academic community, of professional associations and of representative employers of the study programme domain

Knowing and understanding the specific phenomena studied in this course, formation and development of practical abilities to correctly and completely interpret results, practice of the teamwork spirit and of the ability to organise and investigate, nurturing a scientific environment based on values, professional ethics and quality. The course covers the basics of Quantum Field Theory, in preparation of Fields in Interaction (AP2301). Graduates will have knowledge relevant to the understanding of modern-day high-energy particle physics (HEPP) experiments, such as those at CERN and RHIC.

9. Assessment

Activity type	Assessment criteria	Assessment methods	Percent în final mark
9.1. Course	For 50% marks: fundamental notions from this field. For 100% marks: advanced notions from this field.	1. Written evaluation: questions with multiple-choice answers. 2. Oral examination: a) elementary topics; b) advanced topics.	**34%+33%**
9.2 Seminar/laboratory	For 50% marks: fundamental notions from this domain. For 100% marks: advanced notions from this domain.	3. Written evaluation: Problem solving.	**33%**

10.6. Minimum performance standards

50% marks for multiple-choice answer test;
50% marks for problem test;
Oral examination on elementary topics.

Alternatively:

50% marks for multiple-choice answer test;
Written project on one of the course themes.

Minimum attendance: according to the applicable WUT regulations (course 50%; seminar 70%).

Final mark: 34% multiple-choice test, 33% written exam, 33% oral examination. Bonus points awarded for good attendance and for timely homework submission.

Date: 16.09.2022

Signature of Course leader: [redacted]

Signature of Tutorial leader: [redacted]

Signature of Head of Department:

Conf. Dr. habil. Cătălin MARIN