SYLLABUS

1. Information about the study programme

1.1 Institution of higher education	West University of Timisoara
1.2 Faculty	Physics and Mathematics
1.3 Department of	Physics
1.4 Field of study	Physics
1.5 Study cycle	Master
1.6 Study programme	**Advanced research methods in 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. Information about the subject/discipline

2.1 Name	Quantum fields (ARMP1205)						
2.2 Course coordinator	Victor E. AMBRUȘ						
2.3 Seminar coordinator	Victor E. AMBRUȘ						
2.4 Year of study	I	**2.5 Semester**	II	**2.6 Type of assessment**	E[1]	**2.7 Type of discipline**	DS/DOP

3. Total estimated time (hours of teaching per semester)[2]

3.1 Number of hours per week	**4**	**3.2 course**	**2**	**3.3 seminar/laboratory**	**2**
3.4 Total hours in the curriculum	**56**	**3.5 course**	**28**	**3.6 seminar/laboratory**	**28**
Distribution of time:					**hours**
Study based on Instructions, course materials, bibliography and notes					**31**
Additional documentation library, specialized electronic platforms / field					**28**
Training seminars / laboratories, homework, essays, portfolios and essays					**28**
Tutoring					**16**
Examinations[3]					**16**
Other activities					

3.7 Total hours of individual study	**103**
3.8 Total hours per semester[4]	**175**

[1] According to article 37, paragraph (1) of the Higher Education Law no. 199/2023, with subsequent amendments and additions, "the academic success of a student during a study program is determined by verifying the acquisition of the expected learning outcomes through exam-type evaluations and evaluation throughout the semester".

[2] The total number of contact hours and individual study hours will be aligned with the number of credits allocated to the course. One credit corresponds to a total between 25 and 30 hours of teaching activities and individual study. At the level of academic departments may establish, by discipline categories, the exact equivalence between one credit and the number of hours.

[3] The hours corresponding to examinations are added only to the point 3.8 – The total hours per semester, not to be added to the point 3.7 – Total hours of individual study.

[4] Total hours per semester = total hours in the curriculum + total hours of individual study + hours allocated to examinations.

3.9 Number of credits	**7**

4. Prerequisites (where applicable)

4.1 of curriculum	• Complements of Theoretical Physics (ARMP1101); • Complements of Atom and Molecule Physics (ARMP1103);
4.2 of 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. Conditions (where applicable)

5.1 for the course	- The course will take place in physical (face-to-face) format - All course materials will be available on the elearning.e-uvt.ro platform.
5.2 **for the seminar**	- The seminar will take place in physical (face-to-face) format - All seminar materials will be available on the elearning.e-uvt.ro platform.

6. Discipline objectives - expected learning outcomes which contribute to the completion and passing the discipline

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
Skills	• Solving physics problems in given conditions, using analytical and numerical methods • Understanding of fundamental concepts in high-energy particle physics (HEPP)
Responsibility 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

7. Contents

The platform through which the course materials in electronic format and other learning/bibliographic resources can be accessed: https://elearning.e-uvt.ro

7.1. Course	Teaching methods	Comments
Chap.1. Relativistic quantum mechanics (12 hours) • Representations of the Lorentz and Poincare groups. • Noether's theorem. Conserved currents and charges. • Klein-Gordon, Maxwell and Proca equations. • Dirac equation. • Electromagnetic coupling. Non-relativistic limit. • Applications		[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. 2. 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. 3. 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).		

7.2. Seminar	**Teaching methods**	**Comments**
Chap. 1. Relativistic quantum mechanics (12 hours) • Poincare algebra. Induced representations. • Charge current. Energy-momentum tensor. • Pseudo-gauge transformations. • Plane-wave solutions. Green's functions. • Landau levels in a constant magnetic field. • Fine structure splitting.		
Chap. 2. Second quantization (10 hours) • Conserved operators. • Coherent states. • Helicity and chirality. • Coulomb gauge. Casimir effect. • CPT properties of the conserved operators.		
Chap. 3. Thermal field theory (6 hours) • Relativistic statistical mechanics. Partition function. • Finite-temperature Green's functions. • Vortical effects.		
Bibliography See 7.1. Course.		

8. **Corroboration of the course contents with the epistemic expectations of the community representative, professional associations and representative employers of the programme itself**

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. **Use of tools based on generative artificial intelligence**

To complete the tasks defined in the assessment section, the use of generative AII (artificial intelligence instruments) tools is not permitted. The use of AII is permitted and encouraged for documentation during the learning process, complementing but NOT substituting the traditional materials (lecture materials, textbooks in the recommended bibliography). **All generative AI usage for the activities of this module must abide by the Regulation on the use of generative artificial intelligence in the educational process at UVT.**
The most well-known examples of generative AI tools include, but are not limited to: ChatGPT, Google Gemini, Copilot for text, or MidJourney for images.
Each student will specify, in a statement written separately for each assignment, according to the model in Annex 3 of the Regulation on the use of generative artificial intelligence in the educational process at UVT, the tool they used, how it was used, and the part of the assignment in which it was used. The statement will be included by the student at the beginning of the submitted assignment.

10. **Evaluation**

Type of activity	**10.1 Evaluation criteria**	**10.2 Evaluation methods**	**10.3 Percentage of the final mark**
10.4 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%**
10.5 Seminar	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.			

Date of submission:

27.01.2026

Course leader:
Conf. Univ. Dr. Victor E. Ambruș

Signature:

Date of approval in department: **Seminar leader:**

Conf. Univ. Dr. Victor E. Ambruș

Signature:

HEAD OF THE DEPARTMENT:

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