Universitat Autònoma de Barcelona

2018/2019

Advanced Quantum Mechanics

Code: 100178
ECTS Credits: 6

Degree	Type	Year	Semester
2500097 Physics	OT	4	0

Contact

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Use of languages

Principal working language: english (eng)
Some groups entirely in English: Yes
Some groups entirely in Catalan: No
Some groups entirely in Spanish: No

Prerequisites

Recommendation: Quantum physics. Quantum mechanics.

Objectives and Contextualisation

Introduction to quantum field theory. Learn about Klein-Gordon, Dirac and Maxwell fields and equations. Quantum electrodynamics. Elementary tree-level processes.

Skills

- Apply fundamental principles to the qualitative and quantitative study of various specific areas in physics
- Be familiar with the bases of certain advanced topics, including current developments on the parameters of physics that one could subsequently develop more fully
- Carry out academic work independently using bibliography (especially in English), databases and through collaboration with other professionals
- Communicate complex information in an effective, clear and concise manner, either orally, in writing or through ICTs, and before both specialist and general publics
- Develop critical thinking and reasoning and know how to communicate effectively both in the first language(s) and others
- Develop independent learning strategies
- Formulate and address physical problems identifying the most relevant principles and using approximations, if necessary, to reach a solution that must be presented, specifying assumptions and approximations
- Generate innovative and competitive proposals for research and professional activities.
- Respect the diversity and plurality of ideas, people and situations
- Use critical reasoning, show analytical skills, correctly use technical language and develop logical arguments
- Use mathematics to describe the physical world, selecting appropriate tools, building appropriate models, interpreting and comparing results critically with experimentation and observation
- Using appropriate methods, plan and carry out a study or theoretical research and interpret and present the results
- Work independently, have personal initiative and self-organisational skills in achieving results, in planning and in executing a project

- Working in groups, assume shared responsibilities and interact professionally and constructively with others, showing absolute respect for their rights.

Learning outcomes

1. Analyse the consequences of Diracs equation on the nonrelativistic limit.
2. Analyse the limits of simple high and low energy electromagnetic processes.
3. Apply gauge invariance for the Lagrangian determination of quantum electrodynamics.
4. Calculate cross sections for simple electromagnetic processes.
5. Communicate complex information in an effective, clear and concise manner, either orally, in writing or through ICTs, in front of both specialist and general publics.
6. Develop critical thinking and reasoning and communicate ideas effectively, both in the mother tongue and in other languages.
7. Develop independent learning strategies.
8. Establish the bases for the comprehensive formulation of quantum field theory and its applications.
9. Establish the phenomenological consequences of relativistic wave equations.
10. Formulate the bases for the extension to non-Abelian gauge theories.
11. From a specific initial and final state, structure and develop the strategy and calculation for the cross section of an electromagnetic process.
12. Generate innovative and competitive proposals for research and professional activities.
13. Obtain transitional amplitudes for electromagnetic processes using Feynmans rules.
14. Properly handle the algebra of Dirac matrices and the rules for calculating traces.
15. Respect diversity in ideas, people and situations.
16. Study collisions with identical particles.
17. Use critical reasoning, show analytical skills, correctly use technical language and develop logical arguments
18. Use phase-space integration correctly.
19. Work independently, take initiative itself, be able to organize to achieve results and to plan and execute a project.
20. Working in groups, assume shared responsibilities and interact professionally and constructively with others, showing absolute respect for their rights.
21. Carry out academic work independently using bibliography (especially in English), databases and through collaboration with other professionals

Content

Classical Field Theory (Reminder)

Klein-Gordon field. Quantification and propagator.

Dirac field. Quantification and propagator.

Maxwell field. Covariant Formulation. Quantification and propagator.

Quantum Electrodynamics (QED) as gauge field theory.

Dyson expansion of S-matrix. Wick's theorem.

Feynman diagrams and Feynman rules in QED.

Basic processes in QED.

Lorentz symmetry.

Discrete symmetries.

Methodology

This course will be given entirely in English. All the course material (problems, homework and exams) will be distributed in English and students will be encouraged to do all the exercises/exams in English, although in Catalan or Spanish will also be accepted and assesed with the same criteria.

This course will consist of theory and problem classes. There will be an equilibrium among work at class and at home.

Problem lists will be given to be solved individually or in groups. The solutions to the problelms will be discussed in the problem classes.

The students will solve individually and hand in after a limited time a selection of 'homework' problems that will count for the final course mark.

The students will have to prepare 2 written exams: a mid-term exam and a final exam, the latter of which can be re-taken once.

Activities

Title	Hours	ECTS	Learning outcomes
Type: Directed			
Problems class	15	0.6	
Theoretical classes	30	1.2	
Type: Autonomous			
Discussion, work in groups	25	1	
Problems solved in group	31	1.24	
Study of theoretical foundations	42	1.68	

Evaluation

There will be a resit exam for students that: a) have done Exam 1 and Exam 2 and b) have failed the course with a mark of at least 3.5 (over 10). Details on this exam will be announced in due course.

Students not attending Exam 2 will have the mark "Not presented - no avaluable"

Evaluation activities

Title	Weighting	Hours	ECTS	Learning outcomes
Exam 1	35%	2	0.08	2, 1, 3, 4, 5, 7, 6, 8, 9, 11, 16, 10, 12, 14, 13, 17, 19, 18
Exam 2	50%	2	0.08	2, 1, 3, 4, 5, 7, 6, 8, 9, 11, 16, 10, 12, 14, 13, 17, 19, 18
Homework	15%	1	0.04	2, 1, 3, 4, 5, 7, 6, 8, 9, 11, 16, 21, 10, 12, 14, 13, 17, 15, 19, 20, 18
Resit Exam	85%	2	0.08	2, 1, 3, 4, 5, 7, 6, 8, 9, 11, 16, 10, 12, 14, 13, 17, 19, 18

Bibliography

E. Massó, Notes on QFT, (Available in Campus virtual)

Mandl and Shaw, QFT, Wiley

Lahiri and Pal, A first book on QFT