



Academic year	2014-15
Subject	11286 - Quantum Field Theory
Group	Group 1, 1S
Teaching guide	A
Language	English

Subject identification

Subject	11286 - Quantum Field Theory
Credits	1 de presencials (25 hours) 2 de no presencials (50 hours) 3 de totals (75 hours).
Group	Group 1, 1S (Campus Extens)
Teaching period	1st semester
Teaching language	English

Professors

Lecturers	Horari d'atenció alumnes					
	Starting time	Finishing time	Day	Start date	Finish date	Office
Oreste Piro Perusin oreste.piro@uib.es	12:00h	15:00h	Wednesday	01/07/2014	31/07/2015	Mateu Orfila F-320

Contextualisation

Quantum Field Theory (QFT) is the most successful physical framework to understand the world of subatomic particles and their interactions. The ultimate embodiment of this theory is the so called "Standard Model" widely accepted as the most accurate unified description at the quantum level of three of the four fundamental interactions in Nature (namely, the electromagnetic, weak and strong forces) with remarkable predictions whose experimental confirmation is now at the forefront of the fundamental physics. The QFT framework, however, applies to many other branches of physics -outside of high energy physics- wherever systems that involve a large (in fact infinite) number of coupled degrees of freedom arises such as in many instances of Condensed Matter and Statistical Mechanics. This course is an introduction to the collection of techniques developed for QFT as well as to the most striking applications mentioned above. Quantum Field Theory is part of the Quantum Systems module of the Master in Physics (FAMA) at the UIB. The course will be given either in Spanish or English upon students request.

Dr. Oreste Piro earned his PhD in Theoretical Physics at the National University of La Plata, Argentina, in 1984 where he also became professor in 1986. He has a wide and multidisciplinary research experience and his contributions expand over several branches of physics including Particle Physics and Field Theory, Plasma Physics, Dynamical Systems, Fluid Dynamics, Nonlinear Physics, Biophysics, and others. He has worked in several top institutions such as The James Frank Institute (The University of Chicago), Los Alamos National Laboratory, Brookhaven National Laboratory, Queen Mary College at University of London and CNRS-University of Nice, France. Starting in 1980 he has been in charge of many undergraduate and graduate courses spanning almost all areas of theoretical physics. He has more than 100 articles published in high impact journals, with over 1800 citations and a Hirsh number of 24.

Requirements





Recommendable

Its recommended that the students have a solid knowledge of quantum mechanics and methods of mathematical physics at a graduate level.

Skills

Specific

- * ESQ1: Understanding of the basic concepts involved in the quantification of systems with an infinite number of degrees of freedom..
- * ESQ2: Knowledge of the most common analytical tools for quantum fields such as perturbation theory, Feynmann diagrams, renormalization group, etc. as well as their application to the fundamental interactions between elementary particles..
- * ESQ3: Understanding of the basic concepts and techniques inherent in the characterization of interacting quantum systems..

Generic

- * Systematic understanding of a field of study and mastery of skills and methods of research associated with that field..

Basic

- * You may consult the basic competencies students will have to achieve by the end of the Master's degree at the following address: http://estudis.uib.cat/master/comp_basiques/

Content

Theme content

1. Introduction

Classical fields and the need for their quantization. Second quantization. Canonical vs. Path integral quantization.

2. Quantum theory of scalar fields

Quantization of the Klein-Gordon field. Green functions and propagators. Scattering amplitudes, causality and particle creation.

3. Interacting fields and perturbation theory

A simple example of interacting fields: the phi-fourth model. Perturbation theory. Perturbation expansions of correlation functions. The Wick's theorem and Feynmann diagrams. Divergences and their regularization. Renormalization group.

4. Quantization of spinor fields

The Dirac equation. Quantization of the Dirac field. Spin and Statistics. The Dirac propagator. Symmetries. Grassman variables in the path-integral method.

5. Gauge Theories and their quantization.



Global and local phase invariance. The necessity of gauge fields and the minimal substitution. Abelian and non-abelian gauge theories. Quantization of gauge theories. Quantum Electrodynamics. Electro-weak unification and an introduction to the Standard Model.

Teaching methodology

In-class work activities

Modality	Name	Typ. Grp.	Description	Hours
Theory classes	Lectures	Large group (G)	The lecturer will give a basic introduction of the concepts related to each of the course contents and provide with examples and extensions to be elaborated autonomously by the student.	18
Practical classes	Exercises and Seminars	Large group (G)	To guide the student through the solution of problems and exercises related to the course program, and eventually present special topics and monitor the evolution and results of the autonomous self-study.	5
Assessment	Oral Presentation	Large group (G)	The student will orally present the results of his assigned project.	2

At the beginning of the semester a schedule of the subject will be made available to students through the UIBdigital platform. The schedule shall at least include the dates when the continuing assessment tests will be conducted and the hand-in dates for the assignments. In addition, the lecturer shall inform students as to whether the subject work plan will be carried out through the schedule or through another way included in the Campus Extens platform.

Distance education work activities

Modality	Name	Description	Hours
Individual self-study	Individual project	The student will elaborate a subject proposed by the professor and write a detailed report to be submitted for assessment and orally defended.	25
Group or individual self-study	Theoretical complements and exercises	The student will resource to the suggested bibliography to complement the notions presented in the lectures and solve proposed problems and exercises. Both tasks will be logged on a notebook to be submitted for assessment.	25





Specific risks and protective measures

The learning activities of this course do not entail specific health or safety risks for the students and therefore no special protective measures are needed.

Student learning assessment

Oral Presentation

Modality	Assessment
Technique	Oral tests (non-retrievable)
Description	The student will orally present the results of his assigned project.
Assessment criteria	
Final grade percentage:	20% with minimum grade 4

Individual project

Modality	Individual self-study
Technique	Papers and projects (retrievable)
Description	The student will elaborate a subject proposed by the professor and write a detailed report to be submitted for assessment and orally defended.
Assessment criteria	
Final grade percentage:	50% with minimum grade 4

Theoretical complements and exercises

Modality	Group or individual self-study
Technique	Learning file (retrievable)
Description	The student will resource to the suggested bibliography to complement the notions presented in the lectures and solve proposed problems and exercises. Both tasks will be logged on a notebook to be submitted for assessment.
Assessment criteria	
Final grade percentage:	30% with minimum grade 4

Resources, bibliography and additional documentation

Basic bibliography

An Introduction to Quantum Field Theory, Michael E. Peskin & Daniel V. Schroeder, Perseus 1995
Quantum Field Theory, a Modern Introduction, Michio Kaku, Oxford Univ. Press 1993.

Complementary bibliography

The Quantum Theory of Fields Vols I, II and III, Steven Weinberg, Cambridge Univ. Press 2002



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Other resources

Otros recursosDiversos apuntes disponibles en internet.

