COURSE DATA

Data Subject	
Code	43293
Name	Quantum field theory 2
Cycle	Master's degree
ECTS Credits	6.0
Academic year	2021 - 2022

Study (s)

Degree	Center	Acad. year	Period
2150 - Master's degree in Advanced Physics	Faculty of Physics	1	First term

Subject-matter

Degree	Subject-matter	Character
2150 - Master's degree in Advanced Physics	2 - Fundamental interactions	Optional

Coordination

Name	Department
NAVARRO SALAS, JOSE	185 - Theoretical Physics

SUMMARY

In the Quantum Field Theory II course the student will learn the elements of quantum field theory at an advanced level. The course covers the following topics: i) Advanced canonical approach to QFT. Quantum fields and cosmology. ii) Operator approach to QFT. Regularization and renormalization. Renormalization group. iii) Functional integral approach to QFT. Symmetries, Ward identities and anomalies. iv) One-loop divergences and renormalization of QED. v) Non-abelian gauge theories. Perturbative quantization.

Some other advanced aspects QFT may be covered as well.

PREVIOUS KNOWLEDGE

Relationship to other subjects of the same degree

There are no specified enrollment restrictions with other subjects of the curriculum.

Other requirements

COMPETENCES (RD 1393/2007) // LEARNING OUTCOMES (RD 822/2021)

2150 - Master's degree in Advanced Physics

- Students should apply acquired knowledge to solve problems in unfamiliar contexts within their field of study, including multidisciplinary scenarios.
- Students should be able to integrate knowledge and address the complexity of making informed judgments based on incomplete or limited information, including reflections on the social and ethical responsibilities associated with the application of their knowledge and judgments.
- Students should communicate conclusions and underlying knowledge clearly and unambiguously to both specialized and non-specialized audiences.
- Students should demonstrate self-directed learning skills for continued academic growth.
- Students should possess and understand foundational knowledge that enables original thinking and research in the field.
- Ser capaz de gestionar información de distintas fuentes bibliográficas especializadas utilizando principalmente bases de datos y publicaciones internacionales en lengua inglesa.
  ?
  ?
- Saber organizarse para planificar y desarrollar el trabajo dentro de un equipo con eficacia y eficiencia.
  ?
  ?
- Ostentar la preparación para tomar decisiones correctas en la elección de tareas y en su ordenación temporal en su labor investigadora y/o profesional.
  ?
  ?

- Poseer la capacidad para el desarrollo de una aptitud crítica ante el aprendizaje que le lleve a plantearse nuevos problemas desde perspectivas no convencionales.
  ?
  ?
- Estar en disposición para seguir los estudios de doctorado y la realización de un proyecto de tesis doctoral.
  ?
  ?
- Comprender de una forma sistemática el campo de estudio de la Física y el dominio de las habilidades y métodos de investigación relacionados con dicho campo.
- Concebir, diseñar, poner en práctica y adoptar un proceso sustancial de investigación con seriedad académica.
- Realizar un análisis crítico, evaluación y síntesis de ideas nuevas y complejas en el área de la Física.
- Analizar una situación compleja extrayendo cuales son las cantidades físicas relevantes y ser capaz de reducirla a un modelo parametrizado.
- Evaluar la validez de un modelo o teoría propuesto por otros miembros de la comunidad científica.
- Saber modelizar matemáticamente los problemas físicos sencillos nuevos, conectados con problemas conocidos. Ser capaz de expresar en términos matemáticos nuevas ideas.
- Elaborar una memoria clara y concisa de los resultados de su trabajo y de las conclusiones obtenidas en el área de la Física.
- Exponer y defender públicamente el desarrollo, resultados y conclusiones de su trabajo en el área de la Física.
- Saber construir modelos de acuerdo con el contenido en partículas y en simetrías de la ?teoría. Analizar y comprender los límites de validez de las teorías físicas.
- Conocer y saber utilizar la invariancia de gauge local como punto de partida en la ?formulación de las interacciones fundamentales.

LEARNING OUTCOMES (RD 1393/2007) // NO CONTENT (RD 822/2021)

At the end of the teaching-learning process the student will have learned to:

1. Select and correctly use various sources of information in both traditional and electronic format. Know the basics of file own field: inspire, spiers, arXiv.
2. Properly handle and interpret qualitative and quantitative physical data which validate the known theories in the field.
3. Analyze information from physical systems.
4. Prepare documents and reports in a text written in an understandable way organized, documented and illustrated.
5. Articulate oral discourse, structured, consistent, with good diction and use of technical vocabulary.

6. Understand the arguments used in the field of theoretical physics.
7. Understanding the mathematical description of physical processes of particle creation and destruction. Understanding the formalism of quantum field theory in the mathematical description of physical models.
8. Use the basic concept of a constituent of matter. Know how to classify the elementary particles and fundamental interactions.
9. Describe the processes of collision and disintegration of particles at the tree. Being able to develop and use the techniques of approximation in the calculation of particle interactions. Being able to predict physical quantities (cross sections, lifetimes, ...) of particles from a given theory.
10. Understand the concept of particle-mediated interaction and the methodology of quantum field theory.
11. The fundamentals of field quantization in the path integral formalism.
12. The basic principles of renormalization theory and the renormalization group.
13. Understanding the quantization of non-Abelian gauge theories in the functional integral formalism.
14. Improve the understanding of symmetries and operator aspects of quantum field theory.

DESCRIPTION OF CONTENTS

1. Advanced canonical approach to QFT. Quantum fields and cosmology

Canonical quantization. Vacuum energy. Quantum fields under external conditions. QFT in an expanding universe. Particle creation. Conformal symmetry. QFT in de Sitter space. QFT origin of primordial perturbations.

2. Operator approach to QFT. Regularization and renormalization. Renormalization group

S matrix and time-ordered products. LSZ reduction formula. Perturbative expansion. Feynman rules. The Kallen-Lehmann spectral representation.One-loop divergences in scalar field theories. Dimensional regularization. Schwinger-Feynman parametrization. UV divergences and power counting.
Renormalized perturbation theory. Counterterms and renormalization schemes. On-shell and Minimal subtraction schemes. Coupling constant, mass, and wave-function renormalization. Renormalization group.
Beta functions, anomalous dimensions. Running coupling constants.

3. Functional integral approach to QFT. Symmetries, Ward identities and anomalies

Generating functional. Functional integral. Interactions and Feynman rules. Complements. path integrals in quantum mechanics. Gaussian integrals. Gauge invariance. Path integrals for fermions. Path integrals for spin 1 fields. Faddeed-Popov method. Ghost fields. Schwinger-Dyson equations. Symmetries in QFT. Ward identities. Anomalies

4. One-loop divergences and renormalization of QED

Detailed one-loop calculations in QED: vacuum polarization, electron-self-energy, electron-photon vertex. Ward identity.

5. Non-abelian gauge theories. Perturbative quantization

Basic facts about Lie algebras and representations. Non-Abelian gauge theories. Yang-Mills Lagrangian and theta angle. Gauge redundancies and gauge fixing. Quantization of gauge fields by the Faddeed-Popov method. Ghost fields. Feynman rules for gauge theories. BRS symmetry. Renormalization of gauge theories. Beta function of SU(N) Yang-Mills theory.

WORKLOAD

ACTIVITY	Hours	% To be attended
Theory classes	40,00	100
Seminars	3,00	100
Other activities	3,00	100
Development of group work	10,00	0
Development of individual work	11,00	0
Preparing lectures	43,00	0
Preparation of practical classes and problem	40,00	0
TOTAL	**150,00**	

TEACHING METHODOLOGY

English version is not available

EVALUATION

The evaluation of the subject will be based on:

- Written examination on the lectures and practices: based on learning outcomes and specific objectives of the course (50%).

- Continuous evaluation of the student in the lectures and practices: resolution of proposed problems (50%).

REFERENCES

Basic

- T.P Cheng and L.-F.Li, Gauge theory of elementary particle Physics, 1984, Oxford University Press.
- C. Itzykson and J.B. Zuber, "Quantum Field Theory", McGraw-Hill, 1980
- M. E. Peskin and D. V. Schroeder, An Introduction to Quantum Field Theory, Reading, MA: Addison-Wesley (1995).
- M. D. Schwartz, Quantum Field Theory and the Standard Model, Cambridge University Press, 2014
- M. Srednicki, Quantum Field Theory, Cambrdige University Press (2007)
- A. Zee, Quantum Field Theory in a nutshell, Princenton University Press, 2010

ADDENDUM COVID-19

This addendum will only be activated if the health situation requires so and with the prior agreement of the Governing Council

English version is not available