COURSE DATA

Data Subject	
Code	43294
Name	Electroweak interactions
Cycle	Master's degree
ECTS Credits	6.0
Academic year	2022 - 2023

Study (s)

Degree	Center	Acad. year	Period
2150 - M.D. in Advanced Physics	Faculty of Physics	1	First term

Subject-matter

Degree	Subject-matter	Character
2150 - M.D. in Advanced Physics	2 - Fundamental interactions	Optional

Coordination

Name	Department
BOTELLA OLCINA, FRANCISCO JOSE	185 - Theoretical Physics
TORTOLA BAIXAULI, M. AMPARO	185 - Theoretical Physics

SUMMARY

In the Electro-weak Interactions course the student will know the phenomenology of weak interactions. He or she will use the principle of local gauge symmetry to generate the electromagnetic and electro-weak interaction. He or she will study the implementation of spontaneous symmetry breaking as mass generation method. We will study the role of the Higgs boson, the phenomenology of flavor and the matrix of Cabibbo, Kobayashi and Maskawa, the non-conservation of CP symmetry, neutrino physics. The physics beyond the standard model and what we can expect in the LHC particle collider will be also addressed.

PREVIOUS KNOWLEDGE

Relationship to other subjects of the same degree

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

Other requirements

OUTCOMES

2150 - M.D. 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.
- Comprender la teoría electro-débil. Comprender como las interacciones pueden unificarse a partir de las cargas responsables.

LEARNING OUTCOMES

English version is not available

DESCRIPTION OF CONTENTS

1. Chapter 1

Phenomenology of the electroweak interactions. Leptonic, semilieptonic and hadronic selection rules. V-A theory of the charged currents.

2. Chapter 2

Difficulties of the V-A contact theory: Unitarity limit. Vector-boson Mediator. Longitudinal polarizations. Neutral currents. Unification of weak and electrodynamic interactions.

3. Chapter 3

Quautum Electrodynamics. U(1) local gauge principle. Covariant derivative. Photon and electron masses. Vaccum polarization. Anomalous magnetic moment.

4. Chapter 4

Non-Abelian gauge theory. Selfcouplings. SU(2)xU(1) gauge theory for chiral fermions. Charged current couplings.

5. Chapter 5

Neutral currents with electroweak rotation. Electroweak current: electric charge. Relations between gauge couplings. Weak neutral currents. Relations of charged and electromagnetic currents with Zcurrents.

6. Chapter 6

Spontaneous breaking of a global symmetry. Goldstone model. Scalar electrodynamic with spontanous breaking of the local symmetry. Photon mass.

7. Chapter 7

Scalar sector in the SU(2)xU(1) electroweak theory. Spontaneous symmetry breaking. Z and W masses. Unitary gauge. The Higgs boson. Higgs-gauge couplings. Higgs selfcouplings.

8. Chapter 8

Scalar-fermion couplings. Fermionic families. Fermion mass matrices. Diagonalization. Fermionic mass eigenstates. Higgs-fermion couplings.

9. Chapter 9

Cabibbo charged current. Stangeness changing neutral currents?. Need of charm. GIM mechanism. Neutral currents do not change flavour and are universal. Scalar currents preserve flavour but are not universal. Charged currents DO change flavour

10. Chapter 10

Flavour phenomenology. CKM mixing matrix. CP violation. The neutral kaon system.

11. Chapter 11

Left-handed and right handed neutrinos. Neutrinos are different. Neutrino masses and oscillations. Experimental results. Neutrino mass models: Seesaw.

12. Chapter 12

The Standard Model Lagrangian. Feynman rules.

13. Chapter 13

Physics beyond the Standard Model. Grand Unification. Sypersymmetry. What will LHC tell us??

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

MD1 - Standar theory lecture

MD2 - Discussion of articles (readings).

MD3 - Problem solving

MD4 - Problems

MD8 - Conference of experts

EVALUATION

SE1 - Written exam on the theory and practical lectures: based on the results of learning and the specific objectives of each subject (45%).
SE3 - Continuous evaluation of students in the classes of theory and practice: participatory assistance and exercises in the classroom (5%).
SE5 - Evaluation of non-presential activities related to theory and practical lectures: reports (and problems) submitted (45%).
SE7 - Oral presentation and exhibition of works in the classroom (5%).

REFERENCES

Basic

- I. J. R. Aitchison & A. J. G. Hey, "Gauge Theories in Particle Physics" (2 Volume set), Taylor & Francis; 3 edition (January 1, 2004), ISBN-10: 0750309822
- J. Bernabeu & P. Pascual, "Electroweak Theory, GIFT, Sci. Info. Service (1981).
- G. Altarelli, The Standard Electroweak Theory and Beyond, Proceedings of the PSI Zuoz Summer School, "Zuoz 2000, Phenomenology of gauge interactions", arXiv:hep-ph/0011078.
- D. Bailin, "Weak Interactions", (Graduate student series in physics), Taylor & Francis; 2nd edition (June 1, 1982), ISBN-10: 0852745397.
- O. Nachtmann, "Elementary Particle Physics: Concepts and phenomena", Springer (August 1990), ISBN-10: 0387504966.
- A. Pich, The Standard Model of Electroweak Interactions", Lectures given at European School of High-Energy Physics, Aronsborg, Sweden, 18 Jun - 1 Jul 2006, " Aronsborg 2006, High-energy physics", arXiv:0705.4264 [hep-ph].
- C. Quigg, "Gauge Theories Of Strong, Weak, And Electromagnetic Interactions, (Advanced Book Classics), Westview Press (December 15, 1997) ISBN-10: 0201328321.