COURSE DATA

Data Subject	
Code	43291
Name	Elementary particles
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	1 - Introduction to theoretical physics	Optional

Coordination

Name	Department
SANCHIS LOZANO, ALFREDO MIGUEL ANG	185 - Theoretical Physics

SUMMARY

In the course of Elementary Particles the student will learn the phenomenology of elementary particles, how the particles are classified and what are the fundamental interactions. Learn the kinematics of relativistic collision processes and decays. The role of symmetry in both the classification of the particles as in the description of physical processes. A brief introduction to the standard model will be explained, to theories beyond the standard model and astroparticle. Moodern detectors and what the current experiments in particle physics are will be also included in the course.

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.
- Ser capaz de gestionar información de distintas fuentes bibliográficas especializadas utilizando principalmente bases de datos y publicaciones internacionales en lengua inglesa.
- Ostentar la preparación para tomar decisiones correctas en la elección de tareas y en su ordenación temporal en su labor investigadora y/o profesional.
- 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.
- Exponer y defender públicamente el desarrollo, resultados y conclusiones de su trabajo en el área de la Física.
- Conocer la fenomenología de las partículas elementales. Conocer cómo se clasifican las partículas elementales y las interacciones fundamentales. Comprender la relación entre el microcosmos y la formación del macrocosmos.
- Conocer los dispositivos experimentales. Conocer la experimentación con la materia elemental y manejar los resultados.

LEARNING OUTCOMES

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. Knowing the phenomenology of elementary particles. 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.

DESCRIPTION OF CONTENTS

1. Introduction to Elementary Particle Physics

From Democritus to the LHC; Elementary particles and interactions; Baryons and mesons; Scales in the universe

2. Scalar fields

Classical fields adn Lagrangians; Klein-Gordon field; Symmetries and conservation laws; Noether theorem; Relativistic kinematics and Mandelstam variables; exercices; guided work: rapidity and pseudorapidity

3. Fermionic fielkds

The Dirac equation and spinors; Antiparticles and the Dirac sea; The spin of the electron; helicity and the neutrino case; Quirality, parity; The Fermi Lagrangian; Exercises; Guided work: Helicity versus quirality

4. Quantization of free fields

Canonical quantization of the Klein-Gordon field; The vacuum and particle interpretation; The Feynman propagator; Exercices.

5. Interacting fields

Primitive Yukawa theory; phi^4 theory; gauge fields; The Higgs mechanism; Exercises; Guided work: superconductivity analogy of the Hifggs field.

6. The strong interaction and quarks

Isospin. Strangeness. Quark model of hadrons. Parity and Charge Conjugation. Classification of hadrons: multiplets. More flavours

7. The Glashow-Weinberg-Salam model of the electroweak interaction

Fermi contact weak interaction, V-A interaction and massive vector bosons. The GWS Model, the Higgs boson and the origin of mass. Flavour phenomenology.

8. Quantum Chromodynamics and phenomenology of the strong interaction

Dynamical evidence of the existence of quarks: deep inelastic scattering. Why color? QCD as a non-abelian gauge theory. More evidences of color: events with three jets.

9. New Physics (NP) beyond the Standard Model

Summary of the SM and its deficits. Supersymmetry. Dark Matter. The Precision Frontier. The High-Energy Frontier.

10. Cosmology and particles

An overview of the history of the universe. Why inflation? Dark energy and the possible end of the universe.

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

Written exam on the theory and practical lectures: based on the results of learning and the specific objectives of each subject (75% of final grade at least).

Continuous evaluation of students in the classes of theory and practice: resolution of exercises proposed in the classroom (up to 25% of the final grade).

To approve the course a minimum mark of 3 is required in the written exam.

REFERENCES

Basic

- D. H. Perkins, Introduction to High Energy Physics (4th Edition). (Cambridge University Press , Cambridge, 2000)
- F. Halzen and A. D. Martin, Quarks and Leptons: An Introductory Course in Modern Particle Physics. (John Wiley & Sons , New York, 1984)
- Tai-Pei Cheng and Ling-Fong Li, Gauge theory of elementary particle physics, (Oxford University Press, Oxford 1984).
- K. Kleinknecht,, Detectors for Particle Radiation (4th Edition). Cambridge University Press (Cambridge, 1998).
- F. J. Yndurain, Electrones, Neutrinos y Quarks. Ed. Crítica (Madrid, 2001)
- V. Mukhanov, Physical Foundations of Cosmology, (Cambridge University Press ,Cambridge, 2005).
- A.D. Martin and T.D. Spearman, Elementary Particle Theory, (North Holland Pub. Company, Amsterdam 1970).
- Pich, The Standard Model, 2004 CRN Summer Student Lectures. http://humanresources.web.cern.ch/HumanResources/external/recruitment/summies
- Introduction to Elementary Particles
  David Griffiths
  Wiley-VCH