Universitat Autònoma de Barcelona

2018/2019

High Energy Physics

Code: 103947
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

Teachers

Xabier Lobregat Aramburu

Prerequisites

It is recommended to have followed the courses Introduction to Nuclear and Particle Physics (Introducció a la Física Nuclear i de Partícules), Quantum Mechanics (Mecànica Quàntica), Theoretical Mechanics (Mecànica Teòrica i Sistemes No Lineals) and Electrodynamics (Electrodinàmica i Radiació de Sincrotró), and to follow, in parallel, the course Advanced Quantum Mechanics (Mecànica Quàntica Avançada).

It is also recommended to have followed the course Advanced Mathematical Methods (Mètodes Matemàtics Avançats).

Objectives and Contextualisation

The main purpose of this course is to give an introduction to modern particle physics starting from the presentation of what the world is made of and finishing with the formulation of the Standard Model.

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 approaches at tree-level for electroweak and strong simple processes.
2. Analyse the limits of high and low energy for electroweak and strong simple processes.
3. Apply gauge invariance for the Lagrangian determination of electroweak interactions and quantum chromodynamics.
4. Calculate cross sections of electroweak and strong simple 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 Abelian and non-Abelian quantum field theories.
9. Formulate the bases for elementary particle-detection techniques.
10. From a specific initial and final state, structure and develop the strategy and calculation for the cross section of a strong or electroweak process.
11. Generate innovative and competitive proposals for research and professional activities.
12. Obtain transition amplitudes for electroweak and simple strong processes using Feynmans rules.
13. Respect diversity in ideas, people and situations.
14. Use Feynmans rules in strong and electroweak simple processes.
15. Use critical reasoning, show analytical skills, correctly use technical language and develop logical arguments
16. Work independently, take initiative itself, be able to organize to achieve results and to plan and execute a project.
17. Working in groups, assume shared responsibilities and interact professionally and constructively with others, showing absolute respect for their rights.
18. Carry out academic work independently using bibliography (especially in English), databases and through collaboration with other professionals

Content

1) A preview of Particle Physics: general introduction

2) General and formal aspects: relativity, cross section and lifetime, symmetries and conservation laws

3) Quantum numbers and spectroscopy: mass, spin, parity (P), time reversal (T), charge conjugation (C), CP violation, CPT theorem, isospin, hypercharge, the quark model

4) Interactions: electrodynamics of leptons and hadrons, weak interactions, gauge theories, electroweak theory, the Higgs boson, strong interactions

5) Open topics: neutrino oscillations, grand unification, matter/antimatter asymmetry, supersymmetry, strings, extra dimensions, dark matter, dark energy

Methodology

Theory Lectures and Exercises.

Classwork and Homework.

Activities

Title	Hours	ECTS	Learning outcomes
Type: Directed			
Exercises	15	0.6	2, 1, 3, 4, 5, 7, 6, 8, 10, 9, 12, 15, 16, 17, 14
Theory Lectures	30	1.2	2, 1, 3, 4, 6, 10, 12, 15, 14
Type: Autonomous			
Discussion, Work Groups, Group Exercises	30	1.2	2, 1, 3, 4, 5, 7, 6, 8, 10, 18, 9, 11, 12, 15, 13, 16, 17, 14
Study of Theoretical Foundations	60	2.4	2, 1, 3, 4, 7, 8, 10, 9, 12, 15, 16, 17, 14

Evaluation

1st. semester: one exam and one homework;

2nd. semester: one exam and one homework;

In order to participate in the make-up exam you have to be evaluated of the two semester exams.

Evaluation activities

Title	Weighting	Hours	ECTS	Learning outcomes
Exam: 1st. Part	35%	3	0.12	2, 1, 3, 4, 7, 6, 8, 10, 12, 15, 14
Exam: 2nd. Part	35%	3	0.12	2, 1, 3, 4, 7, 6, 8, 10, 12, 15, 14
Homework: 1st. Part	15%	3	0.12	2, 1, 3, 4, 5, 7, 6, 8, 10, 18, 9, 11, 12, 15, 13, 16, 17, 14
Homework: 2nd Part	15%	3	0.12	2, 1, 3, 4, 5, 7, 6, 8, 10, 18, 9, 11, 12, 15, 13, 16, 17, 14
Make-up Exam	70%	3	0.12	2, 1, 3, 4, 7, 6, 8, 10, 12, 15, 14

Bibliography

"Introduction to Elementary Particles", D. Griffiths, Wiley-VCH

"The Standard Model in a Nutshell", D. Goldberg, Princeton Univ. Press

"Quarks and Leptons: An Introductory Course in Modern Particle Physics", F. Halzen and A. D. Martin, John Wiley & Sons