Universitat Autònoma de Barcelona

2022/2023

High Energy Physics

Code: 103947
ECTS Credits: 6

Degree	Type	Year	Semester
2500097 Physics	OT	4	2

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

Arul Prakash Sivagurunathan

Prerequisites

It is recommended to have followed the courses Introduction to Nuclear and Particle Physics, Quantum Mechanics, Theoretical Mechanics and Non-linear Systems, and Electrodynamics and Synchrotron Radiation, and to follow, in parallel, the course Advanced Quantum Mechanics.

It is also recommended to have followed the course Advanced Mathematical Methods.

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.

Competences

- 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
- 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
- Make changes to methods and processes in the area of knowledge in order to provide innovative responses to society's needs and demands.
- Take account of social, economic and environmental impacts when operating within one's own area of knowledge.

- 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. Establish the bases for the comprehensive formulation of Abelian and non-Abelian quantum field theories.
7. Formulate the bases for elementary particle-detection techniques.
8. From a specific initial and final state, structure and develop the strategy and calculation for the cross section of a strong or electroweak process.
9. Identify situations in which a change or improvement is needed.
10. Identify the social, economic and environmental implications of academic and professional activities within one's own area of knowledge.
11. Obtain transition amplitudes for electroweak and simple strong processes using Feynman's rules.
12. Use Feynman's rules in strong and electroweak simple processes.
13. Use Noethers theorem in quantum field theories.
14. Use critical reasoning, show analytical skills, correctly use technical language and develop logical arguments
15. Work independently, take initiative itself, be able to organize to achieve results and to plan and execute a project.
16. Working in groups, assume shared responsibilities and interact professionally and constructively with others, showing absolute respect for their rights.
17. 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.

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Exercises	16	0.64	2, 1, 3, 4, 5, 6, 8, 7, 10, 11, 14, 15, 16, 12
Theory Lectures	33	1.32	2, 1, 3, 4, 6, 8, 7, 9, 11, 14, 12
Type: Autonomous			
Discussion, Work Groups, Group Exercises	29	1.16	2, 1, 3, 4, 5, 6, 8, 17, 7, 10, 9, 11, 14, 15, 16, 12
Study of Theoretical Foundations	57	2.28	2, 1, 3, 4, 6, 8, 7, 9, 11, 14, 15, 16, 12

Assessment

1st. part: one exam and one homework;

2nd. part: one exam and one homework;

In order to participate in the make-up exam you have to be evaluated of the two partial exams without requiring a minimal mark;

The make-up exam covers the whole subject;

You can come to the make-up exam to improve your mark. If so, your final mark will be that of this exam.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Exam: 1st. Part	37,5%	3	0.12	2, 1, 3, 4, 6, 8, 13, 7, 9, 11, 14, 12
Exam: 2nd. Part	37,5%	3	0.12	2, 1, 3, 4, 6, 8, 13, 7, 9, 11, 14, 12
Homework: 1st. Part	12,5%	3	0.12	2, 1, 3, 4, 5, 6, 8, 13, 17, 7, 10, 9, 11, 14, 15, 16, 12
Homework: 2nd. Part	12,5%	3	0.12	2, 1, 3, 4, 5, 6, 8, 13, 17, 7, 10, 9, 11, 14, 15, 16, 12
Make-up Exam	75%	3	0.12	2, 1, 3, 4, 6, 8, 13, 7, 9, 11, 14, 12

Bibliography

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

"Particle Physics", B. R. Martin and G. Shaw, Wiley

"Concepts of Elementary Particle Physics", M. E. Peskin, Oxford Univ. Press

"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

Software

It is recommended to use Mathematica Student Edition.