Standard Model: Fundamentals and Phenomenology

Code: 42864
ECTS Credits: 9

<table>
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<tr>
<th>Degree</th>
<th>Type</th>
<th>Year</th>
<th>Semester</th>
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<tr>
<td>4313861 High Energy Physics, Astrophysics and Cosmology</td>
<td>OT</td>
<td>0</td>
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</table>

Contact

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Teachers

Aurelio Juste Rozas
Immaculada Riu Dachs

Prerequisites

It is recommended to have followed the courses Introduction to the Physics of the Cosmos and Introduction to Quantum Field Theory.

Objectives and Contextualisation

The main purpose of this course is to give an overview of the Standard Model of particle physics starting from the fundamentals and finishing with the phenomenology.

Competences

- Apply the main principles to specific areas such as particle physics, astrophysics of stars, planets and galaxies, cosmology and physics beyond the Standard Model.
- Formulate and tackle problems, both open and more defined, identifying the most relevant principles and using approaches where necessary to reach a solution, which should be presented with an explanation of the suppositions and approaches.
- Understand the bases of advanced topics selected at the frontier of high energy physics, astrophysics and cosmology and apply them consistently.
- Use acquired knowledge as a basis for originality in the application of ideas, often in a research context.
- Use critical reasoning, analytical capacity and the correct technical language and formulate logical arguments.

Learning Outcomes

1. Analyzing the concept of spontaneous breaking of symmetry.
2. Apply chromodynamics of quantum to strong elementary processes.
3. Apply the Weinberg- Salam theory to electroweak elementary processes.
4. Calculate weak and strong electro sections.
5. Recognize the basics of Weinberg- Salam theory of electroweak interactions.
6. Recognize the basis of Quantum Chromodynamics as a theory of strong interactions.

**Content**

**Fundamentals of the Standard Model:**

1. Difficulties of the pre-gauge theory
2. Global and local gauge invariance
3. Spontaneous symmetry breaking, Goldstone bosons and the Higgs mechanism
4. The Standard Model of electroweak interactions
5. Electroweak phenomenology
6. Flavour dynamics
7. Electromagnetic interactions of leptons and hadrons
8. An introduction to Quantum Chromodynamics (QCD)

**Phenomenology of the Standard Model:**

1. QCD in electron-proton collisions
2. QCD in electron-positron collisions
3. Jet algorithms
4. QCD in hadron-hadron collisions
5. Monte Carlo event generators
6. Top physics
7. Higgs physics
8. Heavy flavor physics
9. Neutrino physics

**Methodology**

**Theory Lectures and Exercises.**

**Classwork and Homework.**

**Activities**

<table>
<thead>
<tr>
<th>Title</th>
<th>Hours</th>
<th>ECTS</th>
<th>Learning Outcomes</th>
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</thead>
<tbody>
<tr>
<td>Theory Lectures</td>
<td>68</td>
<td>2.72</td>
<td>1, 2, 3, 7, 6, 5</td>
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<td><strong>Type: Autonomous</strong></td>
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<td></td>
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<tr>
<td>Discussion, Work Groups, Group Exercises</td>
<td>68</td>
<td>2.72</td>
<td>2, 3, 4</td>
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<tr>
<td>Study of Theoretical Foundations</td>
<td>68</td>
<td>2.72</td>
<td>1, 7, 6, 5</td>
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**Assessment**

One exam and one homework of Fundamentals of the SM, and one exam and one homework of Phenomenology of the SM.

In the case of Fundamentals of the SM, the homework will consist on a selected set of exercises.
In the case of Phenomenology of the SM, the homework will consist on an individual presentation about a selected research article.

For those who fail the course it is possible to take a resit examination that will consist on a written exam covering all the content.

In order to take part in this resit exam you have to be evaluated first of the exam and homework of the Fundamentals and Phenomenology parts of the course, respectively.

### Assessment Activities

<table>
<thead>
<tr>
<th>Title</th>
<th>Weighting</th>
<th>Hours</th>
<th>ECTS</th>
<th>Learning Outcomes</th>
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<tr>
<td>Exam Fundamentals</td>
<td>25%</td>
<td>1.5</td>
<td>0.06</td>
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<tr>
<td>Exam Phenomenology</td>
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<td>Resit Exam</td>
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<td>0.12</td>
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</tbody>
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### Bibliography

#### Fundamentals of the Standard Model:

- B. R. Martin and G. Shaw, *Particle Physics*, Wiley

#### Phenomenology of the Standard Model: