Faculty of Science

FYTN18, Theoretical Physics: Theoretical Particle Physics, 7.5 credits

Teoretisk fysik: Teoretisk partikelfysik, 7,5 högskolepoäng

Second Cycle / Avancerad nivå

Details of approval

The syllabus was approved by Study programmes board, Faculty of Science on 2019-11-29 and was last revised on 2020-12-14. The revised syllabus comes into effect 2020-12-14 and is valid from the autumn semester 2021.

General information

The course is for second-cycle studies for a Degree of Master of Science (120 credits) with a specialisation in physics.

Language of instruction: English

Main field of study	*Specialisation*
Physics	A1N, Second cycle, has only first-cycle course/s as entry requirements

Learning outcomes

The purpose of the course is that the student should learn the theoretical basis of the standard model of particle physics and its possible extensions.

Knowledge and understanding

Upon completion of the course, the student shall be able to:

- describe all quarks, leptons and gauge bosons that are included in the standard model as well as the most common hadrons.
- describe the parameters that are included in the standard model and give examples of how they can be measured.
- explain the basics of group theory and how groups can be used to describe symmetries.

- describe how local gauge symmetries, via covariant derivatives, gives rise to interaction terms in the Lagrange density.
- describe the Dirac and Klein-Gordon equations and how they are related.
- describe the different terms in the Lagrange density of the standard model and to which types of processes these lead.
- explain the Higgs mechanism and how particle masses can be introduced in this way.
- explain the concept of asymptotic freedom and how this leads to confinement of quarks and gluons
- describe how quarks are converted into hadrons in scattering experiments.
- explain how and why coupling constants are considered to vary depending on how high energies that are involved in a process
- explain how the existence of neutrino masses can lead to neutrino oscillations.

Competence and skills

Upon completion of the course, the student shall be able to:

- understands how interaction terms in the Lagrange density translates into Feynman diagrams and use this to make estimates of cross-sections for different production, decay, and scattering processes.
- describe how parton density functions are measured and used to calculate cross-sections in hadronic collisions.
- calculate lifetimes and decay widths for the electroweak vector bosons and the Higgs particle and estimate the production cross-section for these particles.
- calculate how the strong coupling decreases with increasing energy and how the electromagnetic coupling increases.
- derive how mixing between quark families is described in the Lagrange density of the standard model, and how mixing between all three quark families leads to that the CP symmetry is not preserved.
- estimate how large the neutrino oscillations become depending on how large the mass differences are.

Judgement and approach

Upon completion of the course, the student shall be able to:

- describe how one, by adding terms in the Lagrange density of the standard model, can study possible extensions of the standard model.
- describe the basic assumptions behind grand unification and supersymmetry and give examples of how astrophysical observations can limit which extensions of the standard model that are possible.
- given a standard model process at a given collision experiment, estimate, based on the Lagrange density of the standard model, how large the cross-section is and how many corresponding events one can expect to observe for a given integrated luminosity.
- by estimating cross-sections, be able to describe which the most important production and decay channels are for the Higgs Particle at the Large Hadron Collider experiments at CERN, and how these depend on the Higgs mass.

Course content

The course deals with theoretical particle physics, especially the following:

- Building blocks of the standard model
- Basic group theory
- Lagrange functions
- The Dirac and Klein-Gordon equations
- The Lagrange density of the standard model
- Cross-sections
- Strong interaction
- Electroweak interaction
- Scale dependence
- CP violation
- Experimental support for the Standard Model
- Neutrino masses and oscillations
- Grand unification and supersymmetry

Course design

The teaching consists of lectures and problem solving sessions.

Assessment

The examination consists of one written exam and two oral exams at the end of the course. Students who do not pass a regular exam are offered a re-exam shortly after the regular exam.

The examiner, in consultation with Disability Support Services, may deviate from the regular form of examination in order to provide a permanently disabled student with a form of examination equivalent to that of a student without a disability.

Grades

Grading scale includes the grades: Fail, Pass, Pass with distinction
To pass the entire course, passed oral exams as well as a passed written exam is required. The final grade is determined by combining the results in the different parts of the examination with the weights 1/3 for the written exam and 1/3 for each of the oral exams.

Entry requirements

The prerequisites required for admission to the course are: 90 credits in Physics and 45 credits in Mathematics or a Bachelor of Science in Physics, in both cases including knowledge corresponding to FYTB14 Classical mechanics and special relativity, 7.5 credits. English 6/B and general entry requirements. Knowledge corresponding to FYSC14 Particle Physics, Cosmology and Accelerators, 7.5 credits is recommended.

Further information

The course may not be credited towards a degree together with FYTN04 Theoretical Particle Physics, 7.5 credits.