LUND UNIVERSITY

Faculty of Science

FYTN04, 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 2007-03-01 (N2007267). The syllabus comes into effect 2007-07-01 and is valid from the autumn semester 2007.

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: Swedish and English
If needed, the course is given in English in its entirety.

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 to give the student the theoretical basis of the standard model of particle physics and its possible extensions.

The aim of the course is that students should have acquired the following knowledge and skills on completion of the course:

- The building blocks of the standard model: The student can describe all quarks, leptons and gauge bosons that are included in the standard model. The student can also describe the most common hadrons and the mutual order of the particles in mass.
- Group theory: The student understands the basics of group theory and how groups can be used to describe symmetries.

- Lagrange functions: The student understands, how local gauge symmetries, via covariant derivatives, gives rise to interaction terms in the Lagrange density and can explain how simple assumptions about symmetry give Maxwell's equations. The student understands how the Dirac equation is treated in the Lagrange density.
- The standard model: The student can describe the different terms in the Lagrange density of the standard model and which types of processes these lead to. The student understands and can explain the Higgs mechanism and how particle masses can be introduced in this way.
- Cross-sections: The student understands how interactions terms in the Lagrange density translates into Feynman diagrams and can use this to make estimates of cross-sections for different production, decay, and scattering processes.
- Strong interaction: The student understands the concept asymptotic freedom and how this leads to confinement of quarks and gluons. The student can describe how quarks are converted into hadrons in scattering experiments. The student understands how parton density functions are measured and used to calculate cross-sections in hadronic collisions.
- Electroweak interaction: The student can calculate lifetimes and decay widths for the electroweak vector bosons and the Higgs particle and can estimate the production cross-section for these.
- Scale breaking: The student can explain how and why coupling constants are considered to vary depending on how high energies that are involved in a process, and explain why the strong coupling decreases with increasing energy while the electromagnetic coupling increases.
- CP violation: The student can derive how mixing between quark families is described in the Lagrange density of the standard model, and how mixing between all three quark families lead to that the CP symmetry is not preserved.
- Experiments: The student can describe the most important experiments within particle physics since around 1980. The student understands which types of particles that can be detected in these experiments and can describe the most common types of detectors.
- Neutrino masses and oscillations: The student understands how the existence of neutrino masses can lead to neutrino oscillations. The student can estimate how large the oscillations become depending on how large the mass differences are.
- Grand unification and supersymmetry: The student can describe how one, by adding terms in the Lagrange density of the standard model, can study possible extensions of the standard model. The student can also describe the basic assumptions behind grand unification and supersymmetry.
- Connections to cosmology and astrophysics: The student should be able to give examples of how astrophysical observations can limit which extensions of the standard model that are possible. The student can estimate how large fraction of the dark matter that can be made up of neutrinos.

Examples of problems that the student should be able to solve upon completion of the course:

- 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.
- Show, by estimating cross-sections, which are the most important production and decay channels for the Higgs Particle at the Large Hadron Collider experiments at CERN, and how these depend on the Higgs mass. Also describe how the Higgs particle can be detected at the experiment in the different channels.
- Describe which parameters that are included in the standard model and give examples of how these can be measured.

Course content

The course consists of the elements described above for a total of 7.5 credits.

Course design

The teaching consists of lectures and problem solving sessions.

Assessment

The examination consists of written hand-in assignments, an oral seminar assignment and an oral test. Students who do not pass the regular exam are offered a re-exam shortly after the regular exam.

Grades

Grading scale includes the grades: Fail, Pass, Pass with distinction
To pass the entire course, a passed oral test, passed written hand-in assignments and passed seminar assignment are required.
The final grade is determined by combining the results in the different parts of the examination.

Entry requirements

The prerequisites required for admission to the course are: English B and general entry requirements as well as knowledge equivalent to 90 credits in physics and 30 credits in mathematics.