LUND UNIVERSITY

Faculty of Science

FYTN10, Theoretical Physics: Introduction to Quantum Field Theory, 7.5 credits

Teoretisk fysik: Introduktion till kvantfältteori, 7,5 högskolepoäng

Second Cycle / Avancerad nivå

Details of approval

The syllabus was approved by Study programmes board, Faculty of Science on 2011-02-07 to be valid from 2011-02-07, autumn semester 2011.

General Information

The course is an elective course 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 studies	*Depth of study relative to the degree requirements*
Physics	A1F, Second cycle, has second-cycle course/s as entry requirements

Learning outcomes

The purpose of the course is to give the student the theoretical concepts, based on quantum mechanics and special relativity theory, that are needed to describe relativistic particles and their interactions.

The aims of the course are that, upon completion of the course, the student should have acquired the following knowledge and skills:

- **Classical field theory:** The student masters the basics of Hamilton and Lagrange formulations of classical field theory and the relation between symmetries of the Lagrange function and conservation laws.
- **Lorentz covariance:** The student understands the importance of formulating theories in a Lorentz invariant way and how this manifests itself for different kinds of fields and other representations of the Lorentz group.
- **Dirac and Klein-Gordon fields:** The student masters the Klein-Gordon and Dirac equations with their different symmetry properties as well as the properties

of the solutions to these. The student understands how scalar and Dirac fields are quantized and can use these to calculate conserved quantities such as energy and momentum. The student understands what a propagator is and how its properties are related to causality as well as how it can be used to describe how a particle moves through space-time. The student understands how currents and densities can be formed from different combinations of Dirac and Klein-Gordon fields. The student can describe how the fields and the creation and annihilation operators are transformed under the charge conjugation, parity and time reversal transformations.

- **Perturbation theory:** The student understands the basic notion of perturbation theory and the meaning of asymptotic states as well as the definitions of cross section and decay width. The student masters the perturbative expansion of correlation functions as well as scattering and decay processes and how these calculations can be simplified using Feynman diagrams for both bosons and fermions. The student masters the Feynman rules for simple theories such as the Yukawa theory and quantum electrodynamics, and understands how they can be derived from the Lagrange density.
- **Quantum electrodynamics:** The student can make simple calculations of processes at tree level such as electron-positron scattering and Compton scattering as well as relating different processes using crossing relations.
- **Radiative corrections:** The student has a basic understanding of how the theory can be reformulated in a consistent way in order to include processes with higher order radiative corrections.

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

- Determine the Hamilton operator for a real Klein-Gordon field from the Lagrange density.
- Verify the transformation properties for a vector and an axial vector current under parity and charge conjugation transformations.
- Show that a time ordered product of scalar and Dirac fields can be written as the sum of a normal ordered product and a propagator.
- Calculate the scattering amplitude for electron muon scattering.
- Explain the relation between the infinite parts of the virtual and real radiative corrections.

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 exercises.

Assessment

The examination consists of written hand-in assignments and an oral theory exam at the end of the course.

Students who do not pass the regular exam are offered a re-examination shortly after the regular exam.

Subcourses that are part of this course can be found in an appendix at the end of this document.

Grades

Marking scale: Fail, Pass, Pass with distinction.
To pass the entire course, it is required to pass both the oral theory exam as well as the written hand-in assignments.

The final grade is determined by the results in the different parts of the examination.

Entry requirements

The prerequisites required for admission to the course are: quantum mechanics (particularly time-dependent perturbation theory) corresponding to FYTA12 (Fundamental Theoretical Physics, 30 credits) or FYSN17 (Quantum Mechanics, 7.5 credits) and advanced knowledge corresponding to at least one of the courses FYTN04 (Theoretical Particle Physics, 7.5 credits) or FYST37 (Advanced Quantum Mechanics, 7.5 credits) as well as English B (advanced proficiency) or the equivalent. It is also recommended to have knowledge in mathematics corresponding to FYTN01 (Mathematical Methods of Physics, 7.5 credits).

Further information

Subcourses in FYTN10, Theoretical Physics: Introduction to Quantum Field Theory

Applies from V11

1101 Introduction to Qutantum Field Theory, 7,5 hp
Grading scale: Fail, Pass, Pass with distinction