Department of Physics

Stockholm University

Syllabus

for course at advanced level

Quantum Field Theory
Kvantfältteori

15.0 Higher Education Credits
15.0 ECTS credits

Course code:	FK8027
Valid from:	Autumn 2017
Date of approval:	2017-03-13
Department	Department of Physics
Main field:	Physics
Specialisation:	A1F - Second cycle, has second-cycle course/s as entry requirements

Decision

This course plan has been established by the Board of Science at Stockholm University on 2017-03-13.

Prerequisites and special admittance requirements

Admission to the course requires knowledge equivalent to a bachelor degree in physics, where the course Advanced Quantum Mechanics, 7.5 credits (FK5027) should be included. Additionally, knowledge equivalent to the courses Analytical Mechanics, 7.5 credits (FK7049) and Electrodynamics, 7.5 credits (FK7045) is required as well as knowledge equivalent to upper secondary school English B/English 6.

Course structure

Examination code	Name	Higher Education Credits
EXAM	Exam	5
HOWO	Homework problems	10

Course content

The course deals with:

Fundamentals of classical field theory:
1) Lagrangian and Hamiltonian formulations of field theory,
2) Space-time symmetries and internal symmetries
3) Noether's theorem on symmetries and conservation laws

Canonical quantization:
1) Free scalar, Maxwell and Dirac fields
2) Electrodynamics as a gauge theory
3) Interacting fields and the S-matrix expansion

Quantum Electrodynamics:
1) Perturbative expansion of the S-matrix
2) Feynman diagrams, Feynman rules, and scattering amplitudes
3) Scattering cross-sections for basic quantum electrodynamic processes at tree level

Strong interactions:

1) Non-Abelian gauge theories
2) Strong interactions and Quantum Chromodynamics

The Electroweak theory:
1) The V-A theory of weak interactions of leptons
2) The SU(2)xU(1) gauge theory,
3) Spontaneous symmetry breaking and Higgs mechanism
4) Fermion and neutrino masses through Yukawa couplings
5) The electroweak unification and simple processes

Path integral formulation of quantum field theory:
1) Functional integrals for free and interacting fields
2) The generating function and its perturbative expansion
3) Non-Abelian gauge fields and the Faddeev-Popov procedure

Learning outcomes

Upon completion of the course, students are expected to be able to:

• Use the relation between symmetries and conservation laws in field theory to compute energy, momentum, spin and charges for various types of fields.

• Provide a mathematical treatment of the quantization of non-interacting scalar, Maxwell, and Dirac fields in the operator formalism, and give an account of the relation between quantized fields and elementary particles.

• Give a mathematical treatment of interacting fields, and of the logical links between S-matrix elements, perturbation theory, Feynman diagrams and rules, scattering amplitudes and cross-sections, and be able to compute tree-level cross-sections for some basic scattering processes in Quantum Electrodynamics.

• Give a mathematical account of non-Abelian gauge theories, and of the Electroweak theory and Higgs mechanism (for leptons), and to compute tree-level cross-sections for some basic electroweak processes.

• Provide a mathematical treatment of the path integral formulation of quantum field theory for interacting bosonic and fermionic fields by using the generating function method, including the Fadeev-Popov procedure for non-Abelian gauge theories.

Education

The education consists of lectures and exercises.

The course will be given in English if requested by any student enrolled.

Forms of examination

a. The course is examined as follows: knowledge assessment takes the form of written and oral exams.

If the instruction is in English, the examination may also be conducted in English.

b. Grades will be set according to a seven-point scale related to the learning objectives of the course:

A = Excellent
B= Very good
C = Good
D = Satisfactory
E = Adequate
Fx = Fail, some additional work required
F = Fail, much additional work required

c. The grading criteria will be distributed at the beginning of the course.

d. In order to pass the course, a minimum grade of E is required.

e. Students who receive a failing grade on a regular examination are allowed to retake the examination as long as the course is still provided. The number of examination opportunities is not limited. Other mandatory course elements are equated with examinations. A student who has received a passing grade on an examination may not retake the examination to attain a higher grade. A student who has failed the same

examination twice is entitled to have another examiner appointed, unless there are special reasons to the contrary. Such requests should be made to the department board.
The course includes at least two examination opportunities per year when the course is given. At least one examination opportunity will be offered during a year when the course is not given.

f. Students awarded the grade Fx are given the opportunity to improve their grade to E. The examiner decides the supplementary assignments to be performed and the pass mark criteria. The supplementary assignments will take place before the next examination session.

Interim

Students may request that the examination be conducted in accordance with this course plan even after it has ceased to be valid. However, this may not take place more than three times over a two year period after course instruction has ended. Requests must be made to the departmental board. The provision also applies in the case of revisions to the course plan (and the revisions of the course literature).

Limitations

The course may not be included as a part of a degree together with the courses Quantum Field Theory, Kvantfältteori, 15 hp (FK8017) or equivalent.

Misc

The course can be included as part of the master's programs offered at the Physics department, but is also offered as a separate course.

Required reading

The course literature is decided by the department board and published on the Department of Physics’s website at least two months before the start of the course.