Quantum Field Theory

Master in physics VUB en KUL

Teacher: Alexander SEVRIN

1. Contents and aim of the course

When studying natural phenomena at small scales one needs quantum mechanics. Similarly the study of physical processes at high energies requires the use of special relativity. In some circumstances - think about elementary particle physics e.g. - one gets confronted with phenomena which simultaneously occur at high energies and small scales. The framework which unifies special relativity with quantum mechanics is relativistic quantum field theory. Quantum field theory is one of the cornerstones of contemporary physics.

This course provides a first introduction to relativistic quantum field theory. Using a concrete and realistic example - quantum electrodynamics - it will develop the basic concepts and techniques allowing the student to microscopically understand the electro-magnetic interaction. Towards the end of the course we will briefly introduce more advanced concepts such as (chiral) non-abelian gauge interactions.

This course is a prerequisite for the courses *Advanced Quantum Field Theory* (KUL/VUB) and *Electroweak and Strong Interactions* (VUB).

The prerequisites for this course are:

- A good knowledge of (non-relativistic) quantum mechanics
- A good knowledge of standard Maxwell theory
- A good knowledge of special relativity
- Knowledge of analytical mechanics (lagrangian, Euler-Lagrange equations, hamiltonian, Poisson brackets, …).

2. Contents

1. Why relativistic quantum field theory?
2. The free Maxwell field
3. The Dirac equation and the Dirac field
4. Fermions and photons in interaction
5. Feynman diagrams and Feynman rules
6. Some basic processes of QED
7. A first invitation to radiative corrections
8. A first meeting with non-abelian interactions and related topics

3. Course material

The course follows the excellent textbook *Quantum Field Theory* by *F. Mandl* and *G. Shaw* (revised edition, December 1993, Wiley, ISBN-10: 0471941867, ISBN-13: 978-0471941866). When called for extra material - in the form of a worked out text - will be provided. This course covers chapters 1 through 8 of the textbook and introduces chapters 9 and 10.

4. Set-up

The course is given during 5 days. Each of these days consists of four lectures of 1,5 hours. The exercises are given in the form of homework which will be graded.

Both in Brussels and in Leuven there will be an instructor for the homework. In Leuven this is Dr. Gabi Honecker, email address: Gabi.Honecker@fys.kuleuven.be . At the VUB it is Alice Bernamonti, email address: abernamo@vub.ac.be.

Normally the course is taught in Dutch unless there are students who do not speak or understand Dutch. In that case the course is given in English.

5. Exam

Homework counts for 25 % of the final score. During the January exam period there will be two exams: one in Leuven (for the KUL students) and one in Brussels (for the VUB students). The exam consists of two exercises which are prepared in written form and is followed by an oral examination. The textbook can be used during the exam.

6. Prakticalities

The course is always given in room G.6.308. This is room 308 on the sixth Floor of building G at the VUB (campus Etterbeek). More details: www.vub.ac.be/infoover/campussen/#campus1 . The lectures start at 9 am and end somewhere between 4 and 5 pm. The course dates are:

1. Thursday October 15
2. Thursday October 29
3. Thursday November 12
4. Thursday November 26
5. Thursday December 10

All students from Leuven wishing to follow this course are asked to send an e-mail to the lecturer. In this way a full mailing list can be established.

7. De docent

The teacher of this course is *Alexander Sevrin*. He studied physics at the State University of Gent. In 1988 he obtained his PhD in theoretical elementary particle physics at the Katholieke Universiteit Leuven. Subsequently he did research in Stony Brook (NY, USA), Berkeley (CA, USA) and CERN (Geneva, Switzerland). Since 1994 he is tenured at the Vrije Universiteit Brussel where he is full professor. His research is devoted to theoretical elementary particle physics with particular emphasis on string theory and related topics.

Email address: *Alexandre.Sevrin@vub.ac.be*
URL : *http://tena4.vub.ac.be/*