

Quantum Field Theory

Master in physics VUB en KUL

Academic year 2014-2015

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 electromagnetic 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. What lies beyond?

3. Course material

The course follows the excellent textbook *Quantum Field Theory* by *F. Mandl* and *G. Shaw* (second edition, Wiley, 2010; ISBN-10: 0471496847, ISBN-13: 978-0471496847). 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 from 9 am through 4 pm. Obviously there will be several breaks... 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 Brussels this is Dr. Anastasios Taliotis (atalioti@vub.ac.be) and in Leuven this is Dr. Alice Bernamonti (Alice.Bernamonti@fys.kuleuven.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 1/3 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. Practicalities

The course is given on the following days:

1. Thursday October 16
2. Thursday October 30
3. Thursday November 13
4. Thursday November 27
5. Thursday December 11

The lectures start at 9 am sharp and end between 3:30 and 4 pm. In the morning the lecture room is F.4.103 and in the afternoon it is F.4.104. These lecture rooms are on the **campus Etterbeek/Pleinlaan** of the VUB. The room code should be read as follows: first letter = building, next number = floor, last number = room number. Travel instructions & maps on: <http://www.vub.ac.be/campus/etterbeek>. If people from Leuven intend to come by car then they should mail me their number plate (the entrance system uses number plate recognition).

All students from Leuven wishing to follow this course are asked to send an e-mail to the lecturer (Alexandre.Sevrin@vub.ac.be) before September 28! In this way a full mailing list can be established (in the future you will receive the homework assignment through this way as well). The Leuven students are requested to register as a guest student: <https://tim4vub.wufoo.eu/forms/enroll-as-guest-student-at-the-vub-20142015/> as well. The VUB code for this course is 4012708FNR.

7. The teacher

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 Catholic University of 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. Since 2011 he is a visiting professor at the Universities of Leuven and Antwerp.

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