

Electroweak and Strong Interactions

Master in Physics (& Astronomy) VUB, UGent and
KULeuven

Academic year 2019-2020

Teacher: Alexander SEVRIN

1. Contents and aim of the course

The Standard Model of Elementary Particle Physics provides a terrific theoretical description of elementary matter particles and their interactions through the electroweak and strong forces. Important notions such as (chiral) non-abelian gauge theories and the Brout-Englert-Higgs mechanism are introduced and applied to the Standard Model. Ample time is spent to the Brout-Englert-Higgs particle and its phenomenology. Flavor physics (CKM matrix, CP violation) and neutrino physics (Majorana and Dirac masses, masses for neutrinos, see-saw mechanism, neutrino oscillations) are thoroughly treated.

The course follows closely current experimental and theoretical insights in the field (in fact it is never more than 24 hours behind the most recent results).

In the last part of the course we turn our attention to “beyond the Standard Model physics”. After analyzing the shortcomings of the Standard Model and introducing regularization, renormalization and the running of coupling constants, we end with an introduction to grand unified theories and supersymmetric extensions of the Standard Model.

The prerequisites for this course are:

- A good knowledge of standard Maxwell theory
- A good knowledge of special relativity
- Knowledge of relativistic quantum field theory (including QED) at an introductory level (i.e. tree level amplitudes, etc.)

2. Course material

The first part of the course continues to follow *Quantum Field Theory* by *F. Mandl* and *G. Shaw* (second edition, Wiley, 2010; ISBN-10: 0471496847, ISBN-13: 978-0471496847). The second part of the course touches upon questions which are directly related to current research (and as a consequence, its precise content changes every year). References to the relevant scientific literature will be given.

3. Set-up

The course is given during 5 days from 9 am through 3-4 pm. Obviously there will be several breaks...

The exercises are given in the form of homework which will be graded. In Brussels, Gent and in Leuven there will be an instructor for the homework. For the students from Brussels and Gent it is Ms Sofia Zhidkova (Sofia.Zhidkova@vub.be), for the students of Leuven this will be Dr. Valentin Reys (valentin.reys@kuleuven.be). Normally the course is taught in English (if all students are native Dutch speakers then obviously, it will be taught in Dutch).

4. Exam

Besides homework there will be a final (short!) paper as well. Together this will count for 1/2 of the final score! During the June exam period there will be (at least) three exams: one (or more) in Brussels (for the VUB students), one (or more) in Leuven (for the KULeuven students) and one (or more) in Gent (for the UGent students). The precise dates will be decided once the course has started. Do not worry, every year again we find date(s) which accommodate all. 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.

5. Practicalities

The lectures are on the following dates, the auditoria are not known yet and will be communicated later on,

1. Tuesday February 11 2020
2. Tuesday February 25 2020
3. Tuesday March 10 2020
4. Tuesday March 24 2020
5. Tuesday April 21 2020

The lectures start at 9 am sharp and end somewhere between 3 and 4 pm. The lectures take place on the Brussels Humanities, Sciences & Engineering Campus (formerly known as campus Etterbeek/Pleinlaan) of the VUB. Travel instructions & maps on: <http://www.vub.ac.be/campus/etterbeek>.

Important notes:

- Could those of you who intend to follow this course send me an email (Alexandre.Sevrin@vub.be) with as subject: "EWS – VUB", "EWS – KULeuven" or "EWS – UGent" (take the one with your home affiliation) so that I get an idea of the number of students who will follow the course (in that way I can be sure that the lecture room is large enough) and set up a mailing list (so I can keep you posted with the practical details). Preferably before Monday February 3 2020 (but the earlier, the better, this is information I need to communicate with you).
- All students from Leuven are requested to register in the usual way in Leuven. In addition you should register as a guest student at the VUB: <https://tim4vub.wufoo.eu/forms/enroll-as-guest-student-at-the-vub/>. Click on "Apply" and follow the (straightforward) instructions. On the second page when asked for "From which programme would you like to follow courses?", you tick "MA Physics&Astronomy (ENG)". On the third page you fill in for the name of the course "Electroweak and Strong Interactions", the catalog number for this course is 4012717CNR and it is a 6 ECTS course. For the students of Brussels and Gent: you register for this course in the usual way.

6. The teacher

The teacher of this course is *Alexander Sevrin*. He got his physics degree at the *University of Gent* in 1985. In 1988 he obtained his PhD in theoretical high energy 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 and the deputy director of the *International Solvay Institutes for Physics and Chemistry*. His research is devoted to theoretical high energy physics with particular emphasis on string theory and related topics. More recently he got closely involved in gravitational wave physics together with colleagues from Leuven, Gent and Antwerp, aiming at getting the future 3rd generation

gravitational wave interferometer at the three country point BE-DE-NL. Since 2011 he is a visiting professor at the *Universities of Leuven and Antwerp*.

Email address: Alexandre.Sevrin@vub.be

Websites: <http://we.vub.ac.be/nl/theoretical-particle-physics> and <http://www.solvayinstitutes.be> and <http://we.vub.ac.be/HEPVUB/>