GHENT UNIVERSITY

Course Specifications

Valid in the academic year 2023-2024

Quantum Electrodynamics (C000819)

Course size *(nominal values; actual values may depend on programme)*

Credits 6.0 **Study time 180 h**

Course offerings and teaching methods in academic year 2023-2024

B (semester 2)	Dutch	Gent	lecture
			group work
			independent work

Lecturers in academic year 2023-2024

Van Neck, Dimitri	WE05	lecturer-in-charge

Offered in the following programmes in 2023-2024	crdts	offering
Master of Science in Teaching in Science and Technology(main subject Mathematics)	6	B
Master of Science in Teaching in Science and Technology(main subject Physics and Astronomy)	6	B
Master of Science in Mathematics	6	B
Master of Science in Physics and Astronomy	6	B

Teaching languages

Dutch

Keywords

Quantum Mechanics, Electromagnetism, Modern Physics, Quantum Electrodynamics, Dirac Theory

Position of the course

The prime goal of this educational unit is to provide a nonrelativistic introduction to quantum electrodynamics. In addition, electromagnetic interactions within the framework of the Dirac equation are also studied.

Contents

Quantum theory of the free e.m.field: Maxwell equations, global and local gauge symmetries, quantization of the e.m.field, state vectors of the e.m.field, coherent states. Interaction between radiation and matter, dipole radiation, photon scattering off electrons, Thompson cross-section, natural linewidth. Second quantization: occupation number representation for bosons and fermions, relation to first quantization, field operators. Interacting quantum fields: Feynmann-Goldstone diagrams. Application for nonrelativistic bremsstrahlung: Coulomb interaction, bremsstrahlung cross-section. Divergences and renormalization in QED: quantumfluctuations, Casimir effect. Renormalization of the electron mass: nonrelativistic approach, Lamb shift, method of Bethe. Electromagnetic coupling using the Dirac equation: minimal coupling, covariant e.m. coupling. Foldy- Wouthuysen transformation: free particle, e.m.field, applicaton to the H-atom. Compton effect, Klein-Nishinaformula, charge conjugation in Dirac theory, particle-antiparticle transformation, hole theory.

Initial competences

Knowledge of non-relativistic quantum mechanics and of classical electromagnetism.
Some familiarity with concepts of modern physics (elementary particles, astrophysics).
Thorough working knowledge of mathematical techniques and calculus is essential.

Final competences

1 Calculate autonomously electromagnetic processes in different branches of modern physics.
2 Have a coherent overview of electromagnetic processes in astrophysics, elementary particle physics, nuclear physics, atomic and molecular physics.
3 Evaluate and apply the contents of the specialized literature on these topics.

4 Give a clear presentation on a chosen subject matter related to QED.
5 Analyze and solve complex problems in QED.

Conditions for credit contract

Access to this course unit via a credit contract is determined after successful competences assessment

Conditions for exam contract

This course unit cannot be taken via an exam contract

Teaching methods

Group work, Lecture, Independent work

Extra information on the teaching methods

Tutorial classes with contributions from the students themselves (project in groups of 2-3 students, about a topic that can be choosen from a list of QED subjects, followed by an oral presentation by the group).

Learning materials and price

Recommended textbook:
Greiner, W., Quantum Mechanics: Special Chapters, Springer - Verlag (2006)
Landau R.H., Quantum Mechanics II, J. Wiley & Sons (1990) (chapters on the Dirac equation and e.m. coupling)
Additional material (handouts)
Cost: 15 EUR

References

F.Gross, Relativistic Quantum Mechanics and Field Theory, Wiley Science Paperback Series, 1999
W. Greiner, D. Bromley, Relativistic Quantum Mechanics (3rd ed.), Springer-Verlag, 2005
W. Greiner, J. Reinhardt, Quantum Eletrodynamics (3rd ed.), Springer-Verlag, 2005

Course content-related study coaching

The students have a continous opportunity for questions and discussion sessions related to the teaching material that is presented during the lectures. A whole set of study books on QED topics can be easily consulted. Review articles and educational papers from the Am.J.Phys. are at the disposal of students. Interactive support through Ufora (e-mail).

Assessment moments

end-of-term and continuous assessment

Examination methods in case of periodic assessment during the first examination period

Oral assessment, Assignment

Examination methods in case of periodic assessment during the second examination period

Oral assessment, Assignment

Examination methods in case of permanent assessment

Participation, Assignment

Possibilities of retake in case of permanent assessment

examination during the second examination period is possible

Extra information on the examination methods

For the permanent evaluation, the student project is extremely important: the individual input, the group activity as well as the contribution to the global result (through presentation and scientific report). Using this method, the student gets a very good idea about his progress in mastering the material.
For the periodical evaluation: the final exam requires an "open book" solution of some serious QED problems. A 2-3 day period is foreseen in order to give students enough time for some research, since the tasks given ressemble a research project to a good extent. At the end all students have to present, individually, their results in an oral discussion session. In this way both the theoretical knowledge and problem-solving capability is tested.

Calculation of the examination mark

Periodical evaluation (weight: 2/3) and also a form of permanent evaluation (weight: 1/3) throughout the year.