

## Subatomic Physics (C004502)

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

**Credits 6.0**

**Study time 180 h**

**Course offerings in academic year 2024-2025**

A (semester 1)

English

Gent

**Lecturers in academic year 2024-2025**

Page, Ben

WE05

lecturer-in-charge

Boone, Matthieu

WE05

co-lecturer

Dobur, Didar

WE05

co-lecturer

Jachowicz, Natalie

WE05

co-lecturer

**Offered in the following programmes in 2024-2025**

**crdts**

**offering**

[Master of Science in Teaching in Science and Technology\(main subject Physics and Astronomy\)](#)

6

A

[Master of Science in Physics and Astronomy](#)

6

A

[Master of Science in Physics and Astronomy](#)

6

A

[Exchange Programme in Physics and Astronomy \(Master's Level\)](#)

6

A

**Teaching languages**

English

**Keywords**

Particle Physics, Nuclear Physics

**Position of the course**

This course builds on the courses 'Particle Physics' and 'Nuclear Physics' in the Bachelor of Physics and Astronomy. Several concepts that were introduced in these courses are studied in more depth. This course prepares for several elective courses in the field of particle physics, nuclear physics and medical physics.

**Contents**

Part 1: Physics of nuclear, particle and medical instrumentation (2 weeks)

- Particle interactions with matter: interactions of heavy charged particles, electron/muon interactions, photon interactions, neutron interactions
- Radiation detection: general properties; detection mechanisms; detector types
- Accelerators and artificial radiation sources: acceleration of charged particles; X-ray tubes; synchrotron radiation

Part 2 : Particle Physics (7 weeks)

- The Dirac Equation and Spin & Helicity & Interaction by Particle Exchange
- Electron – Positron annihilation
- Particle detectors, detection techniques & accelerators (largely discussed in Lecture 1&2)
- Symmetries and the Quark Model & QCD and Colour
- Weak interaction and parity violation & Leptonic Weak Interactions
- Neutrino mixing and Neutrino Oscillations
- Quark mixing and CP Violation
- Electroweak Unification and tests of the Standard Model & The Higgs Boson (~QFT. Phenom.)

Part 3 : Nuclear Physics (3 weeks)

- Nucleon-Nucleon interaction : nucleon-nucleon scattering ; general form of the NN interaction ; the deuteron ; EFT and the NN interaction
- Models of many-body nuclei and nuclear structure : from the NN force to the

nuclear mean field, shell model versus collective models ; beyond the mean field  
: long- and short-range correlations in the nucleus, meson-exchange currents

- Scattering from the nucleus and nuclear excitations : coherent - resonance region - quasi-elastic – resonance excitation and pion production – deep inelastic scattering and duality ; lepton scattering off the nucleus

### Initial competences

The students master the basic principles of subatomic physics. They have a good working knowledge of quantum mechanics and special relativity.

### Final competences

- 1 The students have a good working knowledge of the concepts of subatomic physics.
- 2 They can independently or as a team attack problems in this field. They
  - are able to situate the position of subatomic physics in the description of the microscopic structure of matter
  - explain the role of symmetry in the description of subatomic physics
  - have a thorough knowledge of elementary particles
  - explain various key phenomena in subatomic physics
  - appreciate the structure of subatomic matter at different length and energy scales and observe the synergies and similarities between phenomena and processes at different scales
  - are familiar with the description of leptonic scattering interactions with targets at different scales and why (leptonic) probes provide a powerful tool to study subatomic systems in scattering interactions
  - apply the concepts mentioned above in problems at an intermediate level
  - have a general overview of detection methods and accelerator systems and the physics underlying these systems

### 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

Seminar, Lecture

### Extra information on the teaching methods

Learning material: Lecture notes

### Study material

Type: Handouts

Name: Lecture material

Indicative price: Free or paid by faculty

Optional: no

Additional information: available through Ufora

### References

- Knoll 'Radiation detection and measurement' ; Lilley, 'Nuclear Physics : Principles and applications' ; Leroy and Rancoita, 'Principles of Radiation Interaction in Matter and Detection'
- Modern Particle Physics, Thomson, Cambridge ; Introduction to Elementary Particle Physics, Bettini, Cambridge, 2008 ; Introduction to high energy physics, Perkins, 4th ed., Cambridge ; Particle physics, Martin and Shaw, 2nd ed., Wiley ; Quarks and leptons, Halzen and Martin, Wiley ; Introduction to Elementary Particles, Griffiths, Wiley
- 'Foundations of nuclear and particle physics', T.W. Donnelly et al, Cambridge ; 'Subatomic Physics', Frauenfelder and Henley ; 'Nuclear Physics', Wong ; 'A modern Primer in Particle and Nuclear Physics' F. Terranova, Oxford

### Course content-related study coaching

The students can individually or in group request further explications in between or after lectures. The lecturer can always be reached by e-mail.

### Assessment moments

end-of-term and continuous assessment

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

Written assessment with open-ended questions

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

Written assessment with open-ended questions

**Examination methods in case of permanent assessment**

Written assessment with open-ended questions

**Possibilities of retake in case of permanent assessment**

examination during the second examination period is possible

**Extra information on the examination methods**

The coursework consists of periodic problem sets (open book) and a final written examination which includes a written and oral exam part. The course grade is the weighted average of all homework (15% weight) and the written exam (85% weight).

**Calculation of the examination mark**

Periodical (final exam) 85% + non-periodical (continuous assessment) 15%.

Small deviations from the exact division are possible, depending on the difficulty of the questions in each category.

**Facilities for Working Students**

Lecture slides & book