GHENT UNIVERSITY

Course Specifications

From the academic year 2020-2021 up to and including the academic year

Hadrons and Nuclei from a Theoretical Perspective (C003793)

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

Credits 6.0		**Study time 180 h**		**Contact hrs**	52.5h

Course offerings and teaching methods in academic year 2022-2023

A (semester 2)	English	Gent	lecture	30.0h
			self-reliant study activities	7.5h
			seminar	15.0h

Lecturers in academic year 2022-2023

Ryckebusch, Jan	WE05	lecturer-in-charge

Offered in the following programmes in 2022-2023	**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

Teaching languages

English

Keywords

Nuclear physics, hadron physics, electroweak interactions with nuclei and nucleons

Position of the course

This course is theoretically oriented, and deals with the structure of atomic nuclei and the substructure of its constituent nucleons. After introducing nucleon-nucleon potentials and the atomic nucleus as a many-body system, the focus is on the electroweak interaction as a tool to investigate the structure of nucleons and nuclei.

Contents

1. Introduction: Overview of energy and length scales in subatomic physics./ Nucleons as point particles. Different components of the nuclear force./ Hadronic degrees of freedom: baryons and mesons./ Quark-gluon structure of baryons and mesons.
2. Mathematical and computational tools: Angular momentum algebra. Spherical tensor operators and Wigner-Eckart theorem. Permutation symmetry./ Second quantization. mean-field approximation. Overview of "beyond mean-field" techniques./ Relativistic mean field.
3. Models for the nucleus: Realistic nucleon-nucleon interactions. Short-range repulsion. Nuclear matter./ The deuteron and "few-nucleon" systems./ The shell model for complex nuclei./ Collective motion./ Pairing and superfluidity in nuclei.
4. Electroweak interactions with nuclei: Current-current theorie./ Electroweak nucleon currents./ Electroweak quark currents./ Multipole analysis and long-wavelength approximation./ Neutrino interactions with nuclei./ Final-state interactions.
5. Electroweak interactions with nucleons: Quark models./ Nucleon spectrum./ Electromagnetic and weak nucleon formfactors./ Pion formfactors./ Transition formfactors and helicity amplitudes./ Deep inelastic scattering./ Duality.

Initial competences

At least one course in quantum mechanics and subatomic physics.

Final competences

1 Able to determine the relevant degrees-of-freedom at the various subatomic

scales.

2 Skilled in the use of 3j-, 6j- and 9j-symbols.
3 Able to link models for nucleon-nucleon interactions to scattering experiments and the structure of the deuteron.
4 To grasp the limitations and the successes of the nuclear shell model.
5 Able to understand the microscopic foundations of collective motion in nuclei.
6 Familiarity with the theoretical framework for electroweak interactions with nucleons and nuclei.
7 Fully understand why the electromagnetic probe is such a powerful tool to learn about the structure of nuclei and nucleons.
8 Skilled in the use of the multipole expansion of current-current interaction hamiltonians.
9 Explain the link between hadron and quark models.

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

Online group work, Seminar, Lecture, Self-reliant study activities

Extra information on the teaching methods

The students are expected to study a scientific paper that is related to one of the topics of the course. The content of the scientific paper is explained to all fellow students.

Learning materials and price

Reading material is available through the electronic learning system.

References

"The Nuclear Shell Model", K.L.G. Heyde.
"The Structure of the Nucleon", A. Thomas and W. Weise
"Introduction to Quarks and Partons", F. Close.
"Theoretical Nuclear and Subnuclear Physics", J.D. Walecka
"Subatomic Physics", Hans Frauenfelder and Ernest M. Henley

Course content-related study coaching

The lecturers can be consulted for additional explanations.

Assessment moments

end-of-term and continuous assessment

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

Oral examination

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

Oral examination

Examination methods in case of permanent assessment

Assignment

Possibilities of retake in case of permanent assessment

examination during the second examination period is possible

Extra information on the examination methods

Format of the oral exam:

1 the student receives questions and can work on those for half an hour ; she/he can make use of the course material

2 for half an hour the student is subjected to questions from the examiner

Calculation of the examination mark

- 40% of the total mark for the presentation of a scientific paper
- 60% of the total mark for the oral exam