

## Nuclei: Structure, Synthesis and Interactions (C004507)

**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 2)

English

Gent

**Lecturers in academic year 2024-2025**

Jachowicz, Natalie

WE05

lecturer-in-charge

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

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

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

**crdts**

**offering**

6

A

6

A

**Teaching languages**

English

**Keywords**

Nuclear structure, nuclear reactions, nucleosynthesis

**Position of the course**

This course builds on the courses 'Nuclear Physics' in the Bachelor of Physics and Astronomy and 'Subatomic Physics' in the Master Program in Physics and Astronomy. Several concepts that were introduced in these courses are studied in more depth. The focus is on nucleosynthesis and on the electroweak interaction as a tool to investigate the structure of nucleons and nuclei.

**Contents**

- Low-energy aspects of nuclear structure ; nuclear abundances
- Direct versus resonance reaction mechanisms at low energies
- Beta decay and nuclear structure
- Thermonuclear reaction rates ; Gamow window ; shielding
- Big Bang nucleosynthesis
- Stellar nucleosynthesis (including relevant aspects of stellar structure and evolution) ; nucleosynthesis in the sun, solar neutrinos
- Relativistic mean field description of nuclear structure
- Electroweak interactions with nuclei : Current-current theory, Electroweak nucleon currents, electroweak quark currents, Multipole analysis and long wave length approximation, final state interactions
- The role of atomic nuclei as laboratories for studying fundamental physics processes, relevant experimental efforts

**Initial competences**

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

**Final competences**

- 1 The students have a detailed working knowledge of several concepts in nuclear physics.
- 2 The students can independently or as a team attack problems in this field.
- 3 The students are able to situate the position of nuclear physics in the description of the microscopic structure of matter.
- 4 The students are able to explain various key phenomena in nuclear physics and nucleosynthesis in detail.
- 5 The students are able to describe the main mechanisms for nucleosynthesis in

the universe.

- 6 The students are able show clear understanding of the role of the interplay between nuclear structure and reactionson one hand and stellar structure and evolution on the other, in stellar nucleosynthesis.
- 7 The students are familiar with the theoretical framework for the description of electroweak interactions with nucleons and nuclei.
- 8 The students are familiar with the description of leptonic scattering off nucleons and nuclei, of interactions.
- 9 The students are able to describe why (leptonic) probes provide a powerful tool to study subatomic systems in scattering interactions.
- 10 The students are able to apply the concepts mentioned above in problems at an advanced level.

#### **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

#### **Study material**

Type: Slides

Name: Nuclei : structure, synthesis and interactions

Indicative price: Free or paid by faculty

Optional: no

Oldest Usable Edition : nvt

Available on Ufora : Yes

Type: Handouts

Name: Nuclei : structure, synthesis and interactions

Indicative price: Free or paid by faculty

Optional: no

Language : English

Oldest Usable Edition : nvt

Available on Ufora : Yes

#### **References**

'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, 'An Introduction to Nuclear Astrophysics', R. Boyd, University of Chicago Press ; 'Principles of Stellar Evolution and Nucleosynthesis', D. Clayton, University of Chicago Press ; 'Nuclear Physics of Stars', C. Iliadis, Wiley

#### **Course content-related study coaching**

The lecturer can be contacted after the lectures, or by appointment.

#### **Assessment moments**

end-of-term assessment

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

Oral assessment, Written assessment with open-ended questions

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

Oral assessment, Written assessment with open-ended questions

#### **Examination methods in case of permanent assessment**

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

not applicable

#### **Extra information on the examination methods**

- Written examination to evaluate the knowledge and insight,
- and oral examination to evaluate insight in the matter.
- Open book written examination : problems

**Calculation of the examination mark**

Periodic evaluation 100%