Faculty of Science

# FYSC11, Physics: Atomic and Molecular Physics, 7.5 credits

*Fysik: Atom- och molekylfysik, 7,5 högskolepoäng*

**First Cycle / Grundnivå**

## Details of approval

The syllabus was approved by Study programmes board, Faculty of Science on 2010-12-15 and was last revised on 2016-12-05. The revised syllabus applies from 2016-12-05, spring semester 2017.

## General Information

*Language of instruction:* Swedish and English
The course is given in English unless all students speak Swedish.

| *Main field of studies* | *Depth of study relative to the degree requirements* |
|---|---|
| Physics | G2F, First cycle, has at least 60 credits in first-cycle course/s as entry requirements |

## Learning outcomes

### Knowledge and understanding

On completion of the course, the student should be able to:

- explain the quantum mechanical concepts needed to describe modern atomic and molecular physics
- describe the detailed energy structure of atoms with one or two valence electrons and qualitatively for many-electron systems
- describe some basic experiment from the atom and molecular physics history
- describe how atoms and molecules interact with electromagnetic radiation

### Competence and skills

On completion of the course, the student should be able to:

- use basic quantum mechanical concepts and apply them to the physics of atoms and molecules

- plan, carry out and present experiments
- analyze simple atomic and molecular spectra
- at a general level illustrate and describe current research within atomic physics and synchrotron light physics

### Judgement and approach

On completion of the course, the student should:

- be able to evaluate experimental results
- show an ability to assess the applicability and limitations of physical models
- independently be able to acquire new knowledge and present these in oral or written form
- demonstrate an understanding of the role of atomic physics in society

## Course content

The thematic content of the course:

- The history of atomic physics.
- Basic experiment in atomic physics history e.g. the Stern-Gerlach experiment and Lamb's and Rutherford's experiment.
- Recapitulation of basic quantum mechanical concepts.
- Angular momentum: the electron spin and orbital angular momentum.
- Addition of angular momenta. Clebsch-Gordan coefficients.
- Quantum mechanical treatment of the hydrogen atom, fine structure, the helium atom, spin wave functions, the Pauli principle, LS- and other types of coupling, the central field approximation. Experimental observations of effects connected to these phenomena.
- Electric dipole approximation: Selection rules and relative intensities in radiative transitions.
- X-ray radiation, X-ray spectra, X-ray spectroscopy, Moseley's law.
- Photoelectron spectroscopy.
- Interaction with external magnetic fields, Zeeman and Paschen-Back effect. Hyperfine - and isotope structure.
- Diatomic molecules. The LCAO-method. Molecular orbitals. Quantum mechanical treatment of the energy contributions from rotation and vibration.
- Einstein coefficients: Boltzman distribution, line profiles.
- Laser and applications within laser physics.
- Synchrotron light and applications within synchrotron light physics.
- Applications within astrophysics.
- Laboratory exercises: Zeeman effect, Two-electron spectroscopy and Diode-laser spectroscopy

## Course design

The teaching consists of plenary lectures, group tuition and supervision in connection with laboratory sessions. The lectures are mainly devoted to an overview of the theoretical content, problem-solving and presentation of current research results.

The laboratory work, consisting of the actual experiment and a written report, is compulsory and is graded separately from the theoretical part of the course

## Assessment

The examination routines contain both written hand-ins and a written final test. Three examinations are given per academic year and module.

*Subcourses that are part of this course can be found in an appendix at the end of this document.*

## Grades

Marking scale: Fail, Pass, Pass with distinction.
To pass the entire course requires approved examination, passed laboratory reports and participation in all compulsory parts.

The final grade of the course is decided through a weighted average of the grades for the written examination and the laboratory sessions according to their individual credits.

## Entry requirements

Admission to the course requires the knowledge equivalent to 60 credit points of physics, including the course FYSA21 Tools in Science, 30 credits, or the equivalent.

## Further information

The course may not be included in a higher education degree together with FYSA31 Modern physics, 30 credits, or FYSB04 Atomic and Molecular Physics, 7.5 credits.

## Subcourses in FYSC11, Physics: Atomic and Molecular Physics

Applies from H14

1003 Exam, 5,0 hp
Grading scale: Fail, Pass, Pass with distinction
1004 Laboratory Exercises, 2,5 hp
Grading scale: Fail, Pass, Pass with distinction

Applies from V11

1001 Oral Exam, 5,0 hp
Grading scale: Fail, Pass, Pass with distinction
1002 Laboratory Exercises and Projects, 2,5 hp
Grading scale: Fail, Pass, Pass with distinction