Faculty of Health, Science and Technology
Physics

Syllabus

Course Approval
The syllabus was approved by the Faculty Board of Health, Science and Technology on 5 November 2013 , and is valid from the Autumn semester of 2013 at Karlstad University. It replaces the former syllabus approved on 20 April 2010, Reg No 2010/14:14.

Course Code: FYAD04
Advanced Quantum Mechanics, 7.5 ECTS Credits
(Avancerad kvantmekanik, 7.5 Swedish credit points)
Degree Level: Master
Progressive Specialisation: A1N (Second cycle, has only first-cycle course/s as entry requirements)

Language of Instruction
English or Swedish

Prerequisites
For admission to the course, courses amounting to 60 ECTS credits in physics and 45 ECTS credits in mathematics must have been passed, including the course Quantum Physics I, or eqivalent.

Major Field of Study
FYA (Physics), TKA (Engineering Physics)

Learning Outcomes

A student who has successfully completed the course should be able to:

give an in-depth account of the bra-ket-formalism, the time development of quantum mechanical systems, the measuring process, the Schrödinger and Heisenberg pictures, propagators and gauge transformations
solve the Schrödinger equation and compute the expectation values of various operators for the harmonic oscillator with the help of step operators
describe density matrices and use them in performing basic quantum mechanical calculations for the most relevant types of statistical ensembles
present and reflect on some central questions concerned with the interpretation of quantum mechanics, as well as give an account of Bell's inequalities and their role in that interpretation
give an in-depth account of various issues concerning angular momentum, like the addition of angular momenta, the oscillator model and tensor operators
apply permutation symmetry in the analysis of quantum systems with identical particles
give a detailed description of parity and of space and time inversion, as well as of continuous symmetries and their connection with conservation laws
give an account of and analyse the interaction of quantum systems with electromagnetic radiation as well as with external electric and magnetic fields
apply the most important approximation methods to both time-independent and timedependent quantum mechanical problems and give an account of their respective areas of applicability
give an account of the quantum mechanical description of scattering processers, including the Born approximation and the eikonal approximation

give an outline of the Dirac equation and its solutions for systems with a central potential

Content and Form of Instruction

This course deepens the student's knowledge and proficiency within modern quantum physics, which plays a central role in physics and chemistry, and to some extent in modern biology. The course provides practical knowledge about quantum theory and thereby allows for comprehending complicated properties of matter, both for applications and for continued studies at advanced level.

The course is taught in the form of seminar presentations, lectures and problem solving sessions.

The course comprises the following topics:
- The basic concepts and ideas of quantum mechanics: Hilbert space, the bra-ket-formalism, operators, matrix representation, observables, the measuring tprocess, the uncertainty relation, the position and momentum space representations, density matrices, Bell's inequalities.
- Quantum dynamics: time development, Schrödinger and Heisenberg pictures, step operators for the harmonic oscillator, the propagator, gauge transformations.
- Theory of angular momentum: step operators, spin, addition of angular momenta, the oscillator model, tensor operators.
- Symmetries in quantum mechanics: parity, translations, space and time inversion.
- Approximation methods for time-independent and time-dependent potentials, interaction picture.
- Scattering theory.
- Permutation symmetry, identical particles.
- Introduction to relativistic quantum mechanics, the Dirac equation.
- Short introduction to second quantization and to the quantization of electromagnetic fields.

Reading List

See separate document.

Examination

The grading is based on hand-in assignments, assessment of oral seminar presentations and an oral exam.

Grades

One of the grades U (Fail), 3 (Pass), 4 (Some Distinction), or 5 (Distinction) is awarded to engineering program students. To other students one of the grades U (Fail), G (Pass) or VG (Distinction) is awarded.

Quality Assurance

Follow-up relating to learning conditions and goal-fulfilment takes place both during and upon completion of the course in order to ensure continuous improvement. Course assessment is based on student views and experiences as reported in written course evaluations and/or group discussions. Students will be informed of the result of the evaluation and of the measures to be taken.

Course Certificate

A course certificate will be provided upon request.

Additional Information

Students who enrolled before 1 July 2007 will complete their studies in accordance with the requirements of the earlier admission. Upon completion students may request degree and course certificates to be issued under the current ordinance if they meet its requirements.

The local regulations for studies at the Bachelor’s and Master’s levels at Karlstad University stipulate the obligations and rights of students and staff.

The course is an eligible part of the program Master of Science in Engineering, Degree Programme in Engineering Physics.

Karlstads universitet 651 88 Karlstad, Sweden
Tel +46-54-700 10 00 Fax +46-54-700 14 60
information@kau.se www.kau.se