Faculty of Science

FYST82, Physics: Quantum Information Theory, 7.5 credits

Fysik: Kvantinformationsteori, 7,5 högskolepoäng

Second Cycle / Avancerad nivå

Details of approval

The syllabus was approved by Study programmes board, Faculty of Science on 2023-12-06. The syllabus comes into effect 2023-12-06 and is valid from the autumn semester 2024.

General information

The course is an elective course for second-cycle studies for a Degree of Master of Science (120 credits) with a specialisation in physics.

Language of instruction: English

Main field of study	*Specialisation*
Physics	A1F, Second cycle, has second-cycle course/s as entry requirements

Learning outcomes

The general aim of the course is that the students should acquire knowledge of theoretical concepts and methods in quantum theory and quantum information.

Knowledge and understanding

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

- describe the main directions in quantum information and how these relate to one another
- demonstrate good theoretical understanding of states, measurements and transformations in quantum theory
- give an account of basic quantum information protocols such as teleportation, super-dense encoding and entanglement swapping
- demonstrate good theoretical understanding of quantum mechanical entanglement and non-locality

- name and on a general level explain basic concepts and results in quantum cryptography and other relevant application fields of quantum information.

Competence and skills

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

- apply different mathematical representation forms of quantum transformations
- calculate probability distributions based on general density matrices, measurements and structures on the Hilbert space
- design simple examples of entanglement criteria
- discuss conceptual aspects of non-locality and its relevance for information applications
- use Bell inequalities for simple quantitative calculations of non-locality
- describe communication- and entanglement-based methods for quantum encryption and qualitatively analyse their safety aspects.

Judgement and approach

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

- give an account of the importance of theoretical ideas and methods in quantum information both for conceptualizing quantum physics and for applications in quantum technology.

Course content

The course covers the following theoretical concepts in quantum information:

- mathematical representation theory for quantum mechanical states, measurements and transformations
- entropy and information concepts
- paradigmatic quantum protocols: teleportation, super-dense encoding and entanglement swapping
- initial discussion of quantum mechanical entanglement, especially its detection, quantification and classification
- non-locality: hidden variables, systematic analysis of Bell inequalities and non-locality beyond quantum physics
- BB84 and E91 quantum encryption protocols
- quantum metrology: The Cramér-Rao theorem and quantum Fisher information.

Course design

The teaching consists of lectures and problem solving exercises.

Assessment

Assessment takes place in the form of an oral examination at the end of the course.

Students who do not pass a regular assessment will be offered another opportunity for assessement soon thereafter.

The examiner, in consultation with Disability Support Services, may deviate from the regular form of examination in order to provide a permanently disabled student with a form of examination equivalent to that of a student without a disability.

Grades

Grading scale includes the grades: Fail, Pass, Pass with distinction
For a Pass grade on the whole course, the student must have Pass grade on the exam. Examination is graded according to the scale Fail, Pass, Pass with distinction.

Entry requirements

Admission to the course requires a Bachelor's degree in physics or an equivalent discipline and knowledge equivalent to FMFN01/FYSN27 Quantum Mechanics, 7.5 credits. Furthermore is required English 6/B as well as general entry requirements.

Further information

The course is in full coordinated with FMFN35, Quantum Information Theory, 7.5 credits, which is a course given at Lund Institute of Technology, LTH.

The examination of the course is scheduled in accordance with the examination timetable of the Faculty of Sciences.

The course is offered at the Department of Physics, Lund University.