Lecture

Quantum Systems for Information Technology (QSIT)

spring term (FS) 2016

Lectures & Exercises:
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What is this lecture about?

Quantum Physics and its Applications in Information Processing

Questions:

- How can one use quantum physics to process information and to communicate more efficiently than using classical physics only?
- How does one build physical systems for this purpose?

Is it really interesting?

Even fashion models talk about it!

You do not believe it?

Watch this!

Goals of the Lecture

- understand how quantum physics is used for
  - quantum information processing
  - quantum communication
  - quantum simulation
  - quantum sensing

- know basic features of important quantum algorithms
  - prime number factorization (Shor algorithm)
  - searching in a database (Grover algorithm)
  - simulating quantum systems (Feynman)

- explain protocols for quantum communication
  - efficient information transfer (quantum dense coding)
  - transfer of unknown quantum information (teleportation)
  - secure communication (quantum cryptography)

Goals of the Lecture (continued)

- convey basic concepts of QIP
  - representation of information in qu(antum)bits
  - manipulation and read-out of information stored in qubits

- discuss physical systems used for QIP
  - including photons, atoms, spins, solid state quantum systems
  - know characteristic energy scales and operating conditions
  - know criteria to evaluate suitability of physical systems for QIP

- explore basic experimental techniques to realize and characterize quantum systems
  - realization of quantum devices/systems
  - experimental setups and systems
  - general measurement and characterization techniques

These skills seem to be quite relevant, even in talk shows.

Watch Conan O'Brien and Jim Carrey on the 'Late Night' show.

Tell us about yourself!

- Who are you?
  - Introduce yourself.
  - Which degree program are you in?
    - Physics
    - Micro- and Nanosystems
    - Electrical Engineering & Information Technology
    - Mechanical Engineering
    - PhD
    - Others
  - Where did you do you Bachelor?
    - ETH Zurich
    - Elsewhere (Where?)
  - Do you attend (have you previously attended) classes on Quantum Physics (Exp/Theo) or Quantum Information (Exp/Theo)?
    - Introduction to Quantum Physics (ETH: Physics III, …)
    - Theoretical Quantum Physics (ETH: QM 1, QM 2, …)
    - Quantum Information Processing (FS16: Renner, Home)
    - Quantum Information Theory
    - No prior courses

Basic Structure of QSIT course

Part I: Introduction to Quantum Information Processing (QIP)

- basic concepts: qubits, gate operations, measurement
- circuit model of quantum computation
- examples of quantum algorithms/protocols

Part II: Superconducting Quantum Electronic Circuits for QIP

- qubit realizations, characterization, coherence
- physical realization of qubit control, qubit/qubit interactions and read-out
- interfacing qubits and photons: cavity quantum electrodynamics
- realizations of algorithms and protocols

Part III: Physical Implementations for QIP

- photons in linear optics
- ions and neutral cold atoms
- Electronic and nuclear spins in semiconductor quantum dots, NV centers and molecules

Student Presentations

- Topics: concepts (8 slots) and implementations (14 slots) of experimental quantum information processing
- Goal: present key features of concept or implementation and judge its relevance/prospects
- Material: books, research papers and review articles
- Preparation: teams of two (maybe three) students,
  ~ 22 slots for teams available, advice and support by TAs
- Duration: presentation + discussion (30+15 minutes)
- Presentation: blackboard, transparencies, PowerPoint …
- feedback on both content and presentation of your talk

Exercise Classes

- part I (week 1 - 2)
  - lecture
- part II (week 3 - 13)
  - student presentations
- teaching assistants:
  - Sebastian Krinner (skrinner@phys.ethz.ch)
  - Tobias Thiele (tobias.thiele@phys.ethz.ch)

Reading

- Quantum computation and quantum information
  Michael A. Nielsen & Isaac L. Chuang
  Cambridge : Cambridge University Press, 2000
  676 S.
  ISBN 0-521-63235-8

- additional reading material will be provided throughout the lecture and on the web page: www.qudev.ethz.ch

Credit Requirements

- active contribution to lectures and exercises
- prepare and present a high quality talk on one of the physical implementations of quantum information processing

Exam & Credits

- aural exam (20 mins) during summer or winter exam session
- exam dates as required by your program of study
- 8 credit points (KP) can be earned successfully completing this class
- content of exam:
  - see goals of lecture
  - good presentation and active contribution to lecture will be a bonus

Time and Place

- lecture: Friday (13-15), 12:45 – 14:30, HIT F 13
- exercises: Friday (15-17), 14:45 – 16:30, HIT F 13
- are there timing conflicts with other lectures?

Registration & Contact Information

your registration and contact information

- please register online for the class
- in this way we can contact you

contact information

- qsit-lecture@phys.etzh.ch
- www.qudev.ethz.ch (will be updated constantly)

Let's get started!