QUANTUM SYSTEMS FOR INFORMATION TECHNOLOGY

Organizer: PD Dr. Dima Geshkenbein

1. Quantum bits and gates, quantum circuits, simple algorithms (Deutsch - Josza, entanglement algorithm). — 28.2., 10:00
Student: Björn Beyer, Tutor: Frederic Dupuis.

- original paper introducing the circuit model: D. Deutsch, Quantum computational networks, Proc. R. Soc. London A, vol 425, pp. 73-90, 1989.

- original article proposing the Deutsch-Jozsa algorithm: D. Deutsch and R. Jozsa, Rapid solutions of problems by quantum computation, Proc. R. Soc. London A, 439, 553-558, (1992).

- Chapters 1 and 4 of "Quantum Computation and Quantum Information" by Michael A. Nielsen and Isaac L. Chuang.

- John Preskill's online notes (available at http://www.theory.caltech.edu/people/preskill/ph229/ under "Lecture notes"). Section 6.2 and 6.3 is what this topic is about, and the preceding sections in chapter 6 as background.

2. Quantum cryptography, BB-84. — 28.2., 11:30
Student: Roman Süsstrunk, Tutor: Frederic Dupuis.

- original article C. H. Bennett and G. Brassard, Quantum Cryptography: Public key distribution and coin tossing, in Proceedings of the IEEE International Conference on Computers, Systems, and Signal Processing, Bangalore, p. 175 (1984)
http://www.research.ibm.com/people/b/bennetc/bennettc198469790513.pdf

- Section 12.6 of "Quantum Computation and Quantum Information" by Michael A. Nielsen and Isaac L. Chuang.

- The review article "Quantum Cryptography" available at http://arxiv.org/abs/quant-ph/0601207

3. Quantum error correction. — 7.3., 10:00
Student: Joonas Govenius, Tutor: Johan Aaberg.

- G. Benenti, G. Casati, and G. Strini "principles of Quantum Computation and Information. Vol. II: Basic tools and special Topics" Worlds Scientific, Singapore, (2007).

- P. Shor, "Scheme for reducing decoherence in quantum computer memory", Phys. Rev. A 52, R2493, (1995).

- Chapter. 7 (Secs. 1-9) of J. Preskill's lecture notes,
http://www.theory.caltech.edu/people/preskill/ph229/

- Chapter. 10 (Secs 1-5) of M. A. Nielsen and I. L. Chuang "Quantum Computation and Quantum Information".

4. QM of spin, Zeeman effect, NMR, Rabi oscillations, Ramsey pulses. — 14.3., 10:00
Student: Philipp Bühlmann, Turor: Anton Kozhevnikov.

- Chapter. 15 of L. D. Landau and E. M. Lifshitz, Quantum Mechanics, Vol. 3, §§ 113,114.

- Secs. 2.1.1, 3.3 of "Exploring the quantum : atoms, cavities, and photons" by Serge Haroche, Jean-Michel Raimond, Oxford University Press, 2006.

- Chapter 4 of "Quantum Mechanics" by Claude Cohen-Tannoudji et al.

- Feynman Lectures II, 7.2, Chapter 35

- Chapter 2 "Principles of Magnetic Resonance" by Charles P. Slichter (Springer Series in Solid-State Sciences).

5. Double well, two level systems, Landau Zener tunneling. Correspondence to spin in a field. — 14.3., 11:30
Student: Beni Bissig, Tutor: Martin Eckstein.

- Chapter. 7 of L. D. Landau and E. M. Lifshitz, Quantum Mechanics, Vol. 3, § 50, Problem 3.

- Lectures by Valery Pokrovsky "Semiclassical and Adiabatic Approximation in Quantum Mechanics", Sections II L, IV B.
http://faculty.physics.tamu.edu/valery/quantum2.pdf

- "Landau and modern physics", V. L. Pokrovsky, Physics - Uspekhi 52 (11) 1169 (2009).

- Sec. 2.1.1 of "Exploring the quantum : atoms, cavities, and photons" by Serge Haroche, Jean-Michel Raimond, Oxford University Press, 2006.

- Chapter 4 of "Quantum Mechanics" by Claude Cohen-Tannoudji et al.

6. EPR paradox, Bell inequalities, entanglement. — 21.3., 10:00
Student: Richard Küng, Tutor: Johan Aaberg.

- Peres A. Quantum Theory: Concepts and Methods (Kluwer, Dordrecht, 1993).

- Einstein A., Podolsky B., Rosen N., Phys. Rev. 47, 777 (1935).

- Clauser J.F., Horne M.A. Phys. Rev. D 10, 526 (1974).

- Gisin N. Phys. Lett. A 154, 201 (1991).

- Cirel'son B.S. Lett. Math. Phys. 4, 93 (1980).

7. Quantum dots, Coulomb blockade. — 28.3., 10:00
Student: Daniel Mazzone, Tutor: Andrey Lebedev.

- Chapter 18 of "Semiconductor nanostructures : quantum states and electronic transport" by Thomas Ihn, Oxford University Press, 2010.

- M. A. Kastner, Rev. Mod. Phys. 64, 849 (1992).

- S. M. Reimann, Rev. Mod. Phys. 74, 1283 (2002).

- L. P. Kouwenhoven et al. Rep. Prog. Phys. 64, 701 (2001).

8. Spintronics, spin qubits with quantum dots, decoherence due to nuclear spin. — 28.3., 11.30
Student: Federico Eggenschwiler, Tutor: Andrey Lebedev.

- "Quantum Computing with Electron Spins in Quantum Dots" Robert Andrzej ak, Beat Rhlisberger, Stefano Chesi, and Daniel Loss. Lecture notes for Course CLXXI "Quantum Coherence in Solid State Systems" Int. School of Physics "Enrico Fermi", Varenna, July 2008. Rivista del Nuovo Cimento 033 (Issue 07), 345-399 (2010); arXiv:0906.4045.

9. NMR qubit. — 4.4., 10:00
Student: Szymon Hennel, Tutor: Ludwig Klam.

- Jonathan A. Jones, "Quantum Computation with NMR"
http://nmr.physics.ox.ac.uk/pdfs/torino2.pdf

- Vandersypen and Chuang "NMR techniques for quantum control and computation", Rev. Mod. Phys. 76, 1037 (2004).

- Sac. 7.7 of "Quantum Computation and Quantum Information" by Michael A. Nielsen and Isaac L. Chuang.

- Vandersypen, LMK; et al. "Experimental realization of Shor's quantum factoring algorithm using nuclear magnetic resonance", Nature 414, 883 (2002)

10. Josephson effects, SQUID. — 4.4., 11.30
Student: Markus Legner, Tutor: Ludwig Klam.

- Feynman Lectures, chapter 21-9 "The Josephson junction", p. 21-14 - derivation of the Josephson eq.

- Antonio Barone, Gianfranco Paterno, "Physics and Applications of the Josephson Effect", John Wiley & Sons, Inc., DOI: 10.1002/352760278X, (2005)
http://onlinelibrary.wiley.com/book/10.1002/352760278X;jsessionid=49CDA1DE84FE4A4026966F43C81A9ABA.d01t03
Chapters 1 and 12
- Introduction to SC
- Flux quantisation
- Josephson effect and loop with JJ (more details than Feynman lectures).

- Michael Tinkham "Introduction to superconductivity", Chapter 6.

- Lectures 8 and 9
http://www.pi.uni-karlsruhe.de/ustinov/group_hp/fluxon.physik.uni-erlangen.de/pages/lectures/WS_0708/supercond_lecture.html
- RSCJ-Model

- Review: John Clarke and Frank K. Wilhelm, Superconducting quantum bits, Nature, 453, 1031 (2008)

11. Topological quantum computation. — 11.4., 10:00
Student: Christian Schütte-Nütgen, Tutor: David Gross.

- Chapter 9 of John Preskill's lecture notes which are available online at http://www.theory.caltech.edu/people/preskill/ph229/

12. The Grover algorithm. — 18.4., 10:00

Student: Iwan Gloor, Tutor: David Gross.

- original article: L.K. Grover, Quantum mechanics helps in searching for a needle in a haystack, Phys. Rev. Lett., vol. 79, p. 325-328, 1997.

- Chapter 6 of "Quantum Computation and Quantum Information" by Michael A. Nielsen and Isaac L. Chuang.

13. Quantum Monte-Carlo, spins, bosons, fermions, sign problem. — 18.4., 11:30
Student: Alexander P. Aeberli, Tutor: Lode Pollet.

- worm algorithm:
http://arxiv.org/abs/0910.1393
M. Boninsegni, B. V. Svistunov, and N. V. Prokofev, Phys. Rev. E 74, 036701 (2006)

- there is a very good website at the introductory level :
http://mcwa.csi.cuny.edu/umass/
- and more lecture notes by Prokofev:
http://wiki.phys.ethz.ch/quantumsimulations/#tentative_course_schedule (only the 4 lectures by Prokofev, which cover the overview article above).
- for Spin systems there was a recent review, based on lecture notes by Sandvik:
http://arxiv.org/abs/1101.3281
Chapters 3, 5.1, 5.2

14. Cold atoms, cooling and trapping, BEC. — 2.5., 10:00
Student: Kathrin Gerhard, Tutor: Lode Pollet.

- Chapters 1, 2, 4 of "Bose-Einstein condensation in dilute gases" by C.J. Pethick and H. Smith, Cambridge University Press, 2008.

- M. H. Anderson, et al., "Observation of Bose-Einstein Condensation in

a Dilute Atomic Vapor", Science, 1995. 269: p. 198.

- K. B. Davis, et al., "Bose-Einstein Condensation in a Gas of Sodium Atoms", Phys. Rev. Lett. 75, 3969 (1995).

15. Mott-Hubbard model. — 2.5., 11:30
Student: Jakob Buhmann, Tutor: Martin Eckstein.

- Chapter 14 of "Bose-Einstein condensation in dilute gases" by C.J. Pethick and H. Smith, Cambridge University Press, 2008.

- M. Greiner et al. "Quantum phase transition from a superfluid to a Mott insulator in a gas of ultracold atoms", Nature 415, 39-44 (2002).

16. Atom in a cavity. Jaynes-Cummings model. — 9.5., 10:00
Student: Martin Sepiol, Tutor: Sebastian Schmidt.

- Chapters 10, 11 of "Quantum optics" by D.F. Walls and Gerard J. Milburn, Springer 2008.

- §3.4 of "Exploring the quantum : atoms, cavities, and photons" by Serge Haroche, Jean-Michel Raimond, Oxford University Press, 2006.

- Chapters 2, 4 "Introductory quantum optics" by Christopher Gerry and Peter Knight, Cambridge University Press, 2005.

- Chapters 1, 6 "Quantum optics" by Marlan O. Scully and M. Suhail Zubairy, Cambridge University Press, 2008.

17. Cirquit QED. — 9.5., 11:30
Student: Thomas Blasi, Tutor: Sebastian Schmidt.

- Schoelkopf, RJ and Girvin, SM "Wiring up quantum systems", Nature 451, 664 (2008).

- J. M. Fink et al. "Climbing the Jaynes-Cummings ladder and observing its square root of n nonlinearity in a cavity QED system", Nature 454, 315-318 (2008).

- Alexandre Blais et al. "Cavity quantum electrodynamics for superconducting electrical circuits: an architecture for quantum computation", Physical Review A 69, 062320 (2004).

18. Photon statistics. Hanbury-Brown and Twiss experiments. Glauber States. — 16.5., 10:00
Student: David Perriard, Tutor: Sebastian Schmidt.

- Roy J. Glauber Nobel Prize Lecture:
http://nobelprize.org/nobel_prizes/physics/laureates/2005/glauber-lecture.pdf

- Chapters 1-3 of "Quantum optics" by D.F. Walls and Gerard J. Milburn, Springer 2008.

- Chapters 1, 2, 4 "Quantum optics" by Marlan O. Scully and M. Suhail Zubairy, Cambridge University Press, 2008.

- Chapters 1, 2, 5 "Introductory quantum optics" by Christopher Gerry and Peter Knight, Cambridge University Press, 2005.

19. Superconducting qubits, - charge, phase, flux. — 16.5., 11:30
Student: Fotis Dimitrakopoulos, Tutor: Ludwig Klam.

General, quantum dynamics of Josephson Junctions:

- Michael Tinkham Introduction to superconductivity, Chapter 7.3

- Lectures of Andreas Walraff:

http://www.qudev.ethz.ch/content/courses/QSIT10/QSIT10_V05_slides.pdf

Main subject of the presentation:

Reviews:

John Clarke and Frank K. Wilhelm, "Superconducting quantum bits", Nature, 453, 1031 (2008).

J.Q. You and Franco Nori, "Superconducting Circuits and Quantum Information", Physics Today 58 42 (2005).

Michel H. Devoret and John M. Martinis, "Implementing Qubits with Superconducting Integrated Circuits", Quant. Inf. Proc. 3 163 (2004)

20. Ion traps, Cirac - Zoller. — 23.5., 10:00
Student: Flavia Timpu, Tutor: Anton Kozhevnikov.

- Chapter. 8 of of "Exploring the quantum : atoms, cavities, and photons" by Serge Haroche, Jean-Michel Raimond, Oxford University Press, 2006.

- J. I. Cirac and P. Zoller, "Quantum Computations with Cold Trapped Ions", Phys. Rev. Lett. 74, 40914094 (1995).

- Benhelm, J. et al. "Towards fault-tolerant quantum computing with trapped ions", Nature Physics 4, 463 (2008).

- Leibfried, D. et al. "Experimental demonstration of a robust, high-fidelity geometric two ion-qubit phase gate", Nature 422, 412 (2003).

21. Ion traps, Quantum teleportation. — 23.5., 11:30
Student: Mattia Schaer, Tutor: Anton Kozhevnikov.

- Theory:
C. H. Bennett, C. H. et al. "Teleporting an unknown quantum state via dual classical and EPR channels", Phys. Rev. Lett. 70, 18951899 (1993).

- Experiment:

M. Riebe, et al. "Deterministic quantum teleportation with atoms" Nature 429, 734 (2004).

M. D. Barrett, et al. "Deterministic quantum teleportation of atomic qubits" Nature 429, 737 (2004).