UNIVERSITÀ DI PISA

DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE

Dottorato di Ricerca in Ingegneria dell'Informazione

Doctoral Course

"Quantum Computing"

Prof. Massimo Macucci

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Short Abstract The course has the purpose of providing an understanding of the foundations of quantum computing and quantum communication, and of the nature of the problems for which they can provide an advantage (quantum supremacy) in comparison to their classical counterparts. After covering a few basic concepts in quantum mechanics, we will introduce the concept of the qubit and the basic single- and two-qubit operators. We will then discuss the no-cloning theorem and the teleportation of a state, as well as the implementation of a quantum algorithm with a quantum network. Dense coding, the Deutsch algorithm, and the Shor algorithm will be covered in detail. An example of a basic algorithm for quantum cryptography will also be presented. We will conclude with an overview of the most promising implementations of a quantum computer.

Course Contents in brief:

- States in quantum mechanics, superposition of states, entanglement, Bell's theorem, Dirac notation
- Concept of a universal quantum computer vs. a universal classical computer
- Qubits, single- and two-qubit operators (identity, NOT, Y, Z, Hadamard, generic rotation, controlled NOT)
- No-cloning theorem, teleportation, dense coding scheme
- Oracles and Deutsch algorithm
- Shor algorithm and large number factorization
- Quantum cryptography
- Silicon-based quantum computer
- Quantum computer based on superconducting qubits

Total # of hours: 15

References:

[1] M. A. Nielsen and I. L. Chuang, “Quantum Computation and Quantum Information, Cambridge University Press (2000)

[2] A, Steane, “Quantum Computing,” Rept. Prog. Phys. **61**, 117 (1998).

[3] M. Le Bellac, “A short Introduction to Quantum Information and Quantum Computation,” Cambridge University Press (2006).

CV of theTeacher

Massimo Macucci graduated in Electrical Engineering in 1987 at the University of Pisa, he then obtained the "Perfezionamento" (Doctorate) degree from the Scuola S.Anna-Pisa (1990), and his Master (1991) and Ph.D. (1993) degrees from the University of Illinois at Urbana-Champaign. Since 1992 he has been on the faculty of the School of Engineering of the University of Pisa, currently as Professor of Electronics.

His research interests include novel nanoelectronic semiconductor devices (mainly based on low-dimensional structures), quantum phenomena in semiconductors, and noise phenomena in electronic components and circuits, as well as some aspects of electromagnetic compatibility and of molecular electronics. He is also working on electronics for transportation applications, in particular safety systems for railways and solar-powered aircrafts.

Room and Schedule

Room: *Aula Riunioni del Dipartimento di Ingegneria dell’Informazione*

Schedule:

- 7 maggio 2018 ore 9:30 – 12:30 - Aula Riunioni piano 5 (ex A27) - Largo Lucio Lazzarino
- 8 maggio 2018 ore 14:30 – 17:30 - Aula Riunioni Piano Terra - Via Caruso
- 9 maggio 2018 ore 9:30 – 12:30 - Aula Riunioni Piano Terra - Via Caruso
- 10 maggio 2018 ore 9:30 – 12:30 - Aula Riunioni Piano Terra - Via Caruso
- 11 maggio 2018 ore 9:30 – 12:30 - Aula Riunioni Piano Terra - Via Caruso