Logbook for the course
Quantum computing
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Contents

1 Lecture notes, bibliography, and some additional exercises

1.1 Lecture notes

The document Lecture Notes is a preliminary version of notes written between 2002 and 2017, for different courses taught at the master in mathematics of the *Université de Rennes 1*. The process of writing is still ongoing.

Although these lecture notes are not adapted to the course taught at the *École St Cyr-Coëtquidan*, some chapters can still have some interest to the students attending the SLA-SDI curriculum.

- Chapters 1–4 and 7 and 9 are useful for this cours. These chapters have been updated between September and December 2017
- Part 3, is in an older version using inconsistent notation with respect to the first 4 chapters.

1.2 Bibliography

Other useful sources are the books:

- Michael A. Nielsen and Isaac L. Chuang, Quantum computation and quantum information, Cambridge University Press (2000).
- David McMahon, Quantum computing explained, Wiley-Interscience (2008).

1.3 Additional exercises

Some additional exercises on gates can be found here:

- Examination of 21 January 2016 and its correction.
- Some additional exercises on quantum gates (manuscript notes).
- Examination of 25 January 2017 and its correction.

2 Introduction and motivation

- Short history of computing 1946–today.
- Perspectives.
- Handout of the first lecture.

3 Reminders in classical computing

- Representation of integers as sequences of digits.
- Numerical values of sequences of digits.
- Boolean functions.
- Logical gates and circuits.
- Logical circuit for a addition with carry. ← End of lecture of 15 December 2017.
- Computing with reversible gates.
- Universality of the Fredkin gate.
- SWAP and controlled-NOT (C-NOT) gates.
- Matrix representation of gates.
- Expression of SWAP gates in terms of a cascade of 3 C-NOT gates.

4 Hilbert spaces

- Complex vector spaces.
- Hermitean forms, scalar product on a compex vector space.

- Norm induced by the scalar product.
- Hilbert space.
- Orthonormal families.
- Numerous exercises. ← End of lecture of 20 December 2017.
- Linear operators.
- Classes of operators: normal, self-adjoint, skew-adjoint, unitary.
- Positive operators, projections and orthoporjections.
- Eigenvalues, eigenvectors. ← End of lecture of 09 January 2018.
- Tensor product of Hilbert spaces. Entanglement.
- Dirac's notation.
- Spectral theorem for self-adjoint operators.

5 Quantum mechanics

- Statement of the postulates of quantum mechanics.
- Interpretation of postulates on a simple example.

6 Principles of quantum computing

- Implementation of Boolean functions by logical circuits using gates of small arities.
- Quantum gates and circuits.
  - Hadamard's gate.
  - Phase gate. ← End of lecture of 12 January 2018 (two morning sessions).