Advanced Quantum Mechanics
2020-21

For physicists:

- Advanced Quantum Mechanics (9 CFU): Module 1 + 2 + 3
- New Frontiers in Quantum Mechanics (6 CFU): Module 1 + 2
- Quantum Mechanics and Relativity (3 CFU): Module 3

For mathematicians:

- Introduction to Quantum Mechanics and Quantum Computing (6 CFU): Module 1 + 2

Module 1: From quantum mechanics to quantum computing

- Basics of vector spaces and linear operators
- Quantum Mechanics: an overview from the quantum information point of view
- The qubit
- Quantum computation: quantum gates and circuits
- Simple quantum algorithms
- Quantum Integral transform

References

1. M. Nakahara and T. Ohmi, “Quantum Computing”, CRC Press.
2. M. Nielsen and I. Chuang, “Quantum Computation and Quantum Information”, CUP.
3. P. Kaye, R. Laflamme & M. Mosca, “An Introduction to Quantum Computing”, OUP.

Module 2: Quantum algorithms and more about quantum mechanics

- Grover’s search algorithm
- Shor’s factorization algorithm
- Density matrix formalism
- The Lindblad equation
- Decoherence
- Examples of decoherence processes

References

1. M. Nakahara and T. Ohmi, “Quantum Computing”, CRC Press.
2. M. Nielsen and I. Chuang, “Quantum Computation and Quantum Information”, CUP.
3. P. Kaye, R. Laflamme & M. Mosca, “An Introduction to Quantum Computing”, OUP.
4. H.P. Breuer and F. Petruccione, “The theory of open quantum systems”, Springer
5. M. Schlosshauer, “Decoherence And the Quantum-To-Classical Transition”, Springer.

Module 3: Quantum mechanics and special relativity

- Introduction to relativity

- EPR paradox and Bell's theorem: quantum nonlocality
- No faster than light signaling
- Quantum teleportation
- The no-cloning theorem
- Introduction to quantum cryptography

References

1. More or less any good book in Electromagnetism contains a chapter on Special Relativity. A suggestion is: D. Griffiths, "Introduction to Electrodynamics".
2. A dedicated book on Special Relativity is: W. Rindler "Relativity - Special, General and Cosmological"
3. For the quantum part, Wikipedia and related references are sufficient.