

Advanced Quantum Mechanics

2022-23

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.

Exams.

There will be two written exams in January/February 2022, two written exams in June/July 2022 and two exams in September 2022.

One can take only one exam per session. (Alternatively, I will apply article 27.6 of "Carriera Studente" - <http://web.units.it/node/22080>)

The exam will consist of one theory question for each module. Knowledge of what learnt during the classes should be sufficient to answer successfully the questions. 30 minutes will be given for each question.

A discussion of the written exam will follow.

In addition to the correctness of the answers, also presentation will be evaluated, and it can increase or decrease the final score. It is in your interest to write in a clear and organized way. A concise presentation will be preferred over a uselessly long one.

For any information, related to the course and to the exams, you are welcome to contact me at the email address: abassi@units.it