



UNIVERSITÀ  
degli STUDI  
di CATANIA



DIPARTIMENTO DI FISICA E ASTRONOMIA

DOTTORATO DI RICERCA IN FISICA

ANNO ACCADEMICO 2019 - 2020

## Quantum Technologies

2 CFU

### Teaching staff

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**Reception hours:** Monday 18-20, Wednesday 10-12 (to be confirmed by e-mail)

### Program of the course:

Quantum Technologies (QT) is an interdisciplinary subject where physics, computer science and chemistry merge. In the last decade interest has grown both for the conceptual importance of methods, requiring a deeper understanding of quantum mechanics, and for the enormous potential in applications. QTs aim at exploiting exquisite quantum behavior to perform tasks which are tackled inefficiently by that present day technologies. For instance quantum computation relies on superpositions and entanglement to achieve exponential speedup of certain algorithms, which in a standard digital computer take a time growing exponentially with the input. Quantum communication relies on entanglement and on the unavoidable invasivity of quantum measurement to allow for absolutely secure communication, protected by the laws of Nature. The sensitivity of quantum coherence to external disturbances is the key of a new paradigm of quantum sensors. The course reviews concepts, techniques and physical systems of interest in the field of QT.

- 1) Introductory material (Quantum bits, quantum networks, quantum gates).
- 2) Entanglement and applications to communication.
- 3) Measurement problem and quantum key distribution.
- 4) Digital quantum computation: principles and algorithms.
- 5) Quantum simulators.
- 6) Physical platforms for QTs
- 7) Elements of quantum communication.

### Bibliography:

- [1] M. Nielsen and I. Chuang. Quantum Computation and Quantum Information. Cambridge University Press, Cambridge, 2010.
- [2] S. Haroche and J.M. Raimond, Exploring the Quantum : Atoms, Cavities and Photons, Oxford, 2006.
- [3] G. Chen, D. A. Church, B.-G. Englert, C. Henkel, B. Rohwedder, M. O. Scully, and M. S. Zubairy. Quantum Computing Devices: Principles, Designs and Analysis. Chapman and Hall/CRC, 2007.
- [4] C. P. Williams and S. H. Clearwater, Explorations in Quantum Computing, Springer Verlag, New York, 1998.