



UNIVERSITÀ DI PISA
DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE
Dottorato di Ricerca in Ingegneria dell'Informazione

Doctoral Course

Quantum computing and communication

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Short Abstract:

This course provides participants with the chance to explore quantum computing, communication protocols, and the latest advancements in the field of the quantum internet. Following an initial overview of quantum computing and the current range of computing platforms, participants will delve into algorithms and measurement techniques. The instructor will cover the fundamentals of communication, teleportation, and entanglement. Practical exercises and hands-on experiences are integrated throughout the course.

Course Contents in Brief:

- Circuit Quantum Electrodynamics (QED) and the Jaynes-Cummings Hamiltonian
- Characterization of superconducting qubits, measure coherence and population on multi-level quantum systems
- Analysis of key figures of merit for quantum communication, such as entanglement rate and entanglement generation probability
- Analyze, execute, and debug Python code as they implement various quantum circuits using various software packages.

Total # of hours of lecture: 16 hours (3 days)

References:

- [1] Romanenko, A., et al. "Three-dimensional superconducting resonators at $T < 20$ mK with photon lifetimes up to $\tau = 2$ s." *Physical Review Applied* 13.3 (2020): 034032.
- [2] Alam, M. Sohaib, et al. "Quantum computing hardware for HEP algorithms and sensing." *arXiv preprint arXiv:2204.08605* (2022).
- [3] Koch, Jens, et al. "Charge-insensitive qubit design derived from the Cooper pair box." *Physical Review A* 76.4 (2007): 042319.
- [4] Krantz, Philip, et al. "A quantum engineer's guide to superconducting qubits." *Applied Physics Reviews* 6.2 (2019): 021318.
- [5] Wang, Changqing, et al. "High-efficiency microwave-optical quantum transduction based on a cavity electro-optic superconducting system with long coherence time." *npj Quantum Information* 8.1 (2022): 149.

CV of the Teacher

Full name: Silvia Zorzetti

Email address: zorzetti@fnal.gov

Silvia Zorzetti is a principal engineer at the Fermi National Accelerator Laboratory. She is currently serving as head of the co-design department at the SQMS Division. She also leads the ecosystem and workforce development thrust for the SQMS Center. Dr. Silvia Zorzetti joined Fermilab in 2017 as a Bardeen Fellow. While earning her Ph.D. in electronics engineering and information technology from the University of Pisa, she was a Marie Skłodowska-Curie Fellow at the European Council for Nuclear Research (CERN). Her research focuses on quantum systems to enable applications on long-coherence quantum devices. In 2023, Dr. Silvia Zorzetti received an Early Career Award from the U.S. Department of Energy for her research on quantum transduction devices for the quantum internet.

Final Exam: Yes (details will be given by the lecturer at the course starting day)

Room and Schedule

Room: *Aula Riunioni del Piano 6 del Dipartimento di Ingegneria dell'Informazione - Largo Lucio Lazzarino*

Day 1: 9/7/2024 5.5 hours (9:30-13:00; 14:00-16:00)

Day 2: 10/7/2024 5.5 hours (9:30-13:00; 14:00-16:00)

Day 3: 11/7/2024 5 hours (9:30-12:30; 14:00-16:00)