Postdoc positions available in HQC lab (EPFL-Switzerland)

We, the Hybrid Quantum Circuits-lab (HQC), are looking for a highly motivated post-doctoral researcher to work on the design, fabrication, and characterization of superconducting-semiconducting hybrid devices. This position is immediately available, and we will be continuously evaluating applications.

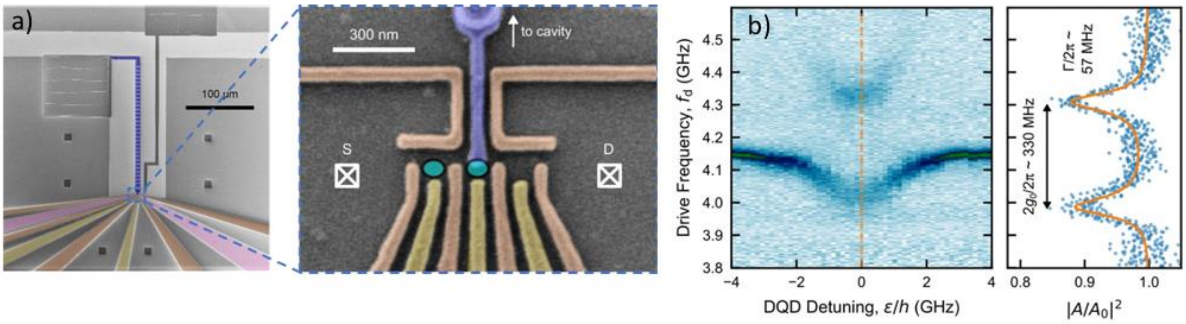

Fig. 1 a) SEM picture of a triple quantum dot (TQD) device coupled to a superconducting frequency-tunable SQUID array resonator. (b) Vacuum-Rabi splitting of the cavity mode, indication of the strong coupling regime.

Project description:

A quantum dot embedded within a circuit quantum electrodynamics (cQED) architecture has emerged as a promising platform not only for quantum information processing but also for studying fundamental light-matter interactions and enabling analog quantum simulations. Recent experiments have successfully demonstrated semiconducting QD-cavity hybrid devices that enable strong coupling between resonator microwave photons and the charge [1,3,4] or spin [2,5,6] degrees of freedom in QDs via their electric dipolar interaction with a microwave resonator. Another highly compelling research direction is achieving ultrastrong coupling [7] between superconducting cavity photons and QD electrons, which could be realized by increasing resonator impedance, enhancing electric field fluctuations, and optimizing gate lever arms.

Our research focuses on double quantum dots (DQDs) defined in planar Germanium and crystal-phase-defined DQDs within InAs nanowires. The strong spin-orbit interaction (SOI) in these semiconducting materials simplifies spin qubit design by enabling fast spin manipulation using electrical signals and eliminating the need for micromagnets.

Leveraging these properties, strong coupling of charge qubits [8] and singlet-triplet qubits [9] in this system to microwave photons has recently been demonstrated, paving the way for further advancements in quantum technology.

The postdoctoral project has two main objectives:

- Maximize light-matter interaction strength, aiming to exceed 1 GHz coupling with the charge degree of freedom and approach the bare resonator and qubit energies (4–8 GHz), thereby entering the ultrastrong coupling regime.
- Utilize photons as a quantum bus to achieve long-distance spin-spin entanglement.

These goals will be pursued by:

- Increasing resonator impedance using superconducting Josephson junctions/SQUID arrays and compact GrAl resonators.
- Enhancing the coupling lever arm between the resonator and the double quantum dot (DQD) through optimized gate design.

Achieving ultrastrong coupling will create a unique platform for probing fundamental physics and advancing quantum technology applications. Success in this endeavor could open new avenues for research at the interface of semiconductor and superconducting quantum technology. The long-term aim of the project is to coherently integrate these two platforms, greatly expanding the range of problems addressable by solid-state quantum hardware and proposing innovative strategies for quantum information technology.

References

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Job description / Responsibilities

The successful candidate will integrate nanowire quantum dots devices with superconducting high impedance resonators. The fabrication of semiconducting QDs (including manipulation and transfer of nanowires) and microwave superconducting devices will be realized in the Center of Micro-Nanotechnology (CMi) cleanroom at EPFL, equipped with all the conventional tools for nanofabrication. We will have access to high-quality semiconducting materials through our project partners at Lund University and University of Basel. The hybrid structures will be tested in a dilution refrigerator at 10 mK via cryogenic and room temperature microwave electronics. The candidate will perform low-noise cryogenic low- and high-frequency measurements to characterize the coupling of charge and spin artificial atoms with a multimode high impedance environment. To succeed, the candidate will leverage our in-house expertise in nanofabrication, state-of-the-art microwave measurements, and collaborative network available within our research groups.

The candidate may be responsible for:

- Device fabrication using e-beam lithography and subtractive processes.
- Manipulation and assembly of nanowires and 2D dielectrics.
- Concept, circuit design and physical design of microwave superconducting circuits.
- Microwave and time-domain characterization measurements.

Profile/Qualifications:

We are seeking candidates with a strong interest in quantum technology based on semiconducting/superconducting quantum circuits. Proficiency in English, in reading, writing and discussing scientific material is essential, along with strong teamwork and excellent communication skills.

- PhD in physics, quantum engineering, or electrical engineering, ideally with a focus on semiconducting/superconducting devices
- Extensive experience in nanofabrication, cryogenics, microwave design, microwave measurements. Skills in fabrication of nanowire-based quantum devices would be a plus.
- Strong general research skills with the ability to conduct independent research
- Ability to collaborate effectively within a team and with collaborators
- Demonstrated initiative, results-oriented mindset, organizational skills, and creativity
- Proficiency in programming language for data analysis

Application procedure

The application should be written in English. The application should be sent electronically to pasquale.scarlino@epfl.ch and be attached as pdf-files, as below: CV, including education, previous employments, publication list, contact details of at least two references. Personal letter where you: introduce yourself, describe your previous research fields and main research results and describe your future goals and future research focus.

For questions, please contact:

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