Hybrid quantum networks: interfacing photons, phonons, and superconducting qubits

Mohammad Mirhosseini, Caltech

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Superconducting quantum circuits are among the most promising architectures for building a quantum computer. In addition, the strong coupling between superconducting qubits and microwave photons provides an ideal platform for studying interaction of light with artificial quantum matter. Despite steady progress in qubit coherence time, control, and measurement within the last two decades, the state-of-the-art superconducting systems remain limited to 50-100 qubits, a number that substantially limits the scope of near-term experiments.

A promising strategy toward further scaling the complexity of quantum circuits is to provide an efficient means of interfacing qubits with other existing physical platforms for storing quantum information, such as optical photons and microwave-frequency phonons. Interfacing qubits with optical photons provides a mechanism for long-distance information transfer in room-temperature environments, a functionality that is absent in cryogenic microwave systems. Likewise, entangling qubits with long-lived phonons in engineered solid-state devices can be leveraged for building quantum memories and miniaturized on-chip interconnects. Developing such new functionalities for quantum information applications goes hand-in-hand with fundamental research in quantum physics. For example, the slow propagation velocity of sound waves can be utilized for studying quantum optics in the non-Markovian regime, where the dynamics of a quantum system is strongly affected by presence of quantum feedback.

I will present results from my research on engineering interactions between distant qubits on a chip, and on interfacing qubits with hypersonic phonons and optical photons. I will conclude by outlining an overview of my future research directions.

Watch a video of the talk here.