

Northwestern Quantum Week Opening Science Workshop: Superconducting Qubits for Quantum Computing

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Johannes Pollanen leads the [Laboratory for Hybrid Quantum Systems \(LHQS\)](#) at Michigan State University (MSU) where his research group investigates the fundamental physics and quantum information applications of systems comprised of trapped electrons, superconducting qubits, and hybrid quantum acoustic systems. Prof. Pollanen holds the Cowen Distinguished Chair in Experimental Physics and also serves as the Co-Director of the [MSU Center for Quantum Computing Science and Engineering \(MSU-Q\)](#) and is a co-founder and board member of the [Midwest Quantum Collaboratory \(MQC\)](#). Additionally he is a co-founder and Chief Science Officer (CSO) of [EeroQ Corporation](#), which is a quantum computing startup company located in Chicago working on building a scalable quantum processor based on the spins of electrons trapped above the surface of superfluid helium. Before joining the faculty at MSU, Pollanen was a IQIM Postdoctoral Scholar at the [Institute for Quantum Information and Matter \(IQIM\) at Caltech](#). Pollanen received his Ph.D. from Northwestern University.

Hybrid quantum phononics with superconducting qubits*

Details: Superconducting qubits, and the experimental architecture of circuit quantum electrodynamics (cQED), have emerged as not only a promising platform for quantum computation but also for investigating fundamental and applied aspects of synthetic/hybrid quantum systems composed of qubits coupled to other quantum systems or degrees of freedom. In particular, the ability to leverage the properties of superconducting qubits to investigate and manipulate phononic degrees of freedom opens the door to exploring new regimes of circuit quantum optics using high-frequency sound. Due to the intrinsically strong nonlinearity provided by the qubit, these types of hybrid “quantum acoustic” systems have the potential to access a broad class of quantum states of motion beyond what is achievable with effectively linear optomechanical or electromechanical interactions.

In this talk I will describe experimental results investigating the fundamental physics of hybrid systems based on superconducting qubits coupled to piezoelectric surface and bulk acoustic wave devices and how these systems can be used to develop next-generation technologies for quantum sensing, computation, and communication. As I will describe, these engineered systems, in which quantum information stored in the qubit can be controllably coupled to the microscopic surface and

bulk phonon modes of a piezoelectric crystal, are an ideal platform for investigating the exotic behavior of synthetic open quantum systems and phononic interference in the quantum regime. Additionally, I will describe how these devices pave the way to exciting new technologies ranging from quantum-limited surface sensing to phonon-based bosonic quantum memories.

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