

---

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

April 20, 2026 | Northwestern University

Archana Kamal

**Archana Kamal** leads the QUantum Engineering Science and Technology (QUEST) Group at Northwestern University. Her research interests span both fundamental and applied aspects of quantum information processing with a focus on developing theoretical tools for leveraging and studying non-equilibrium quantum effects in systems ranging from superconducting qubits, to interacting field theories to many-body condensed matter. Her research has led to new designs of noise-resilient artificial atoms (or “qubits”) and new protocols for high-efficiency information routing and nonreciprocal amplification. Her contributions to nonreciprocal quantum signal processing were recognized by MIT Technology Review with a TR35 – Global Innovator Award in 2018. She is also the recipient of AFOSR Young Investigator and NSF CAREER awards.

---

### Left-handed Josephson Metamaterials: from novel quantum amplifiers to long-range quantum electrodynamics

**Abstract:** Originally introduced for linear optical applications, such as subwavelength focusing and resonance cone formation, left-handed (or negative index) metamaterials have largely remained a non-entity in quantum and nonlinear optics. In this talk, I will motivate how left-handed Josephson metamaterials can enable new functionalities for multi-qubit control and readout. To this end I will present two applications for left-handed Josephson transmission lines, inspired by multimode superconducting circuit design. First, I will discuss our recent proposal for a left-handed Josephson traveling wave parametric amplifier (J-TWPA). Crucially, nonlinear phase matching happens autonomously in left-handed J-TWPA, making it a high-efficiency amplifier that can exhibit high gains over GHz bandwidths. Besides being shorter and more efficient than its right-handed counterparts, left-handed J-TWPA also eschews the need for complicated circuit or dispersion engineering alleviating a critical bottleneck in device footprint and fabrication complexity. In addition, left-handed J-TWPA constitutes a versatile platform for broadband squeezing generation due to its natural suppression of power-dependent nonlinear phase modulation and higher harmonics.

In the second part of my talk, I will discuss how left-handed transmission lines can realize a unique platform to implement strong nonlocal interactions between distant qubits. Notably, we find hitherto unreported algebraic localization of qubit-photon bound states and accelerated light cones for scattering states in a system comprising an emitter coupled to a left-handed Josephson waveguide, with the interaction range and scale of these effects controlled via an interplay between

UV and IR cut-off scales of the waveguide. Our results highlight how Josephson metamaterial engineering can be leveraged to significantly broaden the design landscape of broadband nonlinear devices and implement resource-efficient multi-qubit information processing.

