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Quantum Computing and Simulations with Superconducting Qubits

Superconducting qubits are one the prominent platforms for constructing a multi-qubit quantum processor. In a superconducting circuit, conduction electrons condense into a macroscopic quantum state, such that currents and voltages behave quantum mechanically. In these lectures, first, I explain the basic physics of superconducting qubits, their fabrication process, and circuit-based modeling of quantum circuits. Next, I show how a system of coupled qubits can be used in quantum simulation applications. By discussing some of our recent experiments, I show how the capabilities to perform wave function initialization, Hamiltonian generation, and measurements in different bases allows us to perform a comprehensive study of many-body localization. Last, if time permitting, I explain the physics of the quantum supremacy experiment and the criteria for its successful demonstration.