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Entanglement and Quantum Error Correction with Superconducting Qubits

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Quantum information science seeks to take advantage of the properties of quantum mechanics to manipulate information in ways that are not otherwise possible. Quantum computation, for example, promises to solve certain problems in days that would take a conventional supercomputer the age of the universe to decipher. This power does not come without a cost however, as quantum bits are inherently more susceptible to errors than their classical counterparts. Fortunately, it is possible to redundantly encode information in several entangled qubits, making it robust to decoherence and control imprecision with quantum error correction. I studied one possible physical implementation for quantum computing, employing the ground and first excited quantum states of a superconducting electrical circuit as a quantum bit. These transmon" qubits are dispersively coupled to a superconducting resonator used for readout, control, and qubit-qubit coupling in the cavity quantum electrodynamics (cQED) architecture. In this talk I will give an general introduction to quantum computation and the superconducting technology that seeks to achieve it before explaining some of the specific results reported in my thesis. One major component is that of the first realization of three-qubit quantum error correction in a solid state device, where we encode one logical quantum bit in three entangled physical qubits and detect and correct phase- or bit-flip errors using a three-qubit Toffoli gate. My thesis is available at arXiv:1311.6759.