**Superconducting Circuits for Quantum Information**

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### Quantum Information

Experimental quantum information:
- a fast-developing field where we directly manipulate the quantum state of isolated systems based on the Schrödinger equation.

Current technology
- from rocket to CPUs

Future technology?
- Quantum machines

The basic building block: quantum bit

The Hamiltonian by design!

- Superconductor
- Infusulator
- Cooper pairs

Collective current/voltage excitations $\rightarrow$ described by $|\psi\rangle$

### Equipment, Devices and Experimental methods

- Microwave electronics
- Dilution refrigerator
- Evaporator for device fabrication
- Josephson junction
- 3D quantum circuit architecture

### Study of Decoherence and Superconductivity

Does a quantum state in the lab live forever?
- Energy relaxation $\rightarrow$ $T_1$ time
- Dephasing $\rightarrow$ $T_\phi$ time

We identify various unintended coupling between our qubits and external degrees of freedom to improve the coherence times. This is also often a rewarding process to learn more about our solid state system.

Example:
- Non-equilibrium quasiparticle excitations in our superconducting qubits can cause qubit decay, but a few vortices can help remove them.

### Controlling Mesoscopic Entangled States

Heard of Schrödinger’s cat?
- Nowadays we can place objects a little more macroscopic than qubits into superposition or entangled states!

Two-mode cat state:
- $|\psi\rangle = \frac{1}{\sqrt{2}} \left( |\alpha\rangle_A |\alpha\rangle_B + \frac{1}{\sqrt{2}} |\alpha\rangle_A - \alpha\rangle_B \right)$

Joint Wigner function

- simultaneously “alive”
- simultaneously “dead”
