Quantum Computing

Tuesday, April 10, 2018 5:26 PM

Hello! : I'm Prof. Hess!
- Please interrupt me... often! with questions.
- Prof. Kimmel has told me what excellent "question askers" you are, so don't hold back.
- Take a look at P Set early
  - Some questions will benefit from "stewing on".
- NO Class Friday
- Sign attendance sheet

- Lets start with some brainstorming

Q: What properties are required for a good Quantum Computing hardware?

A:
- Qubits! (Two-level Quantum systems)
- Control of single Qubits (qubit rotations, single qubit gates)
- Interactions (Gates) Between Qubits
- "Scalability": Lots of Qubits
- Isolation from "Environment"
  - ↳ Keep it quantum

- Low error rate
- Error correction
- High Fidelity initialization (10)
- High Fidelity Measurement
- Fast Gates
- Slow "Decoherence"

For today: we will explore 4 Technologies:

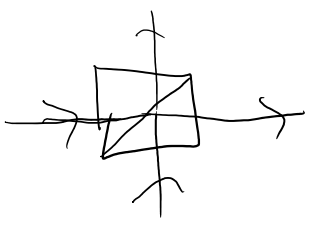
- Photonic Qubits
- Trapped Ion Qubits
- Superconducting Qubits
- Topological Qubits

Photonic Qubits

- Ingredients

Qubit: Polarization: ↑ ↓ → H

Connections:

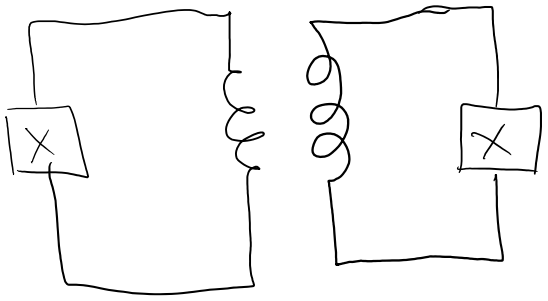


"Beamsplitter"

Advantages: "The flying qubit"

Problems: • Hard to scale
• Lossy

Superconductors: (IBM, Google, D-Wave, Regetti, Northrup Grumman)



Ingredients:

~~Qubit~~: X ≡ Superconducting Josephson Junction.
- Current is quantized

Connections: { { ≡ Coupled Inductors

- Like an microwave antenna in a cell phone.
- Pick up the signal that the other is broadcasting.

Advantages:

- Fast Gates
- Clear Path to scalability in fab
  - With enough effort

Disadvantages:

- Need to be cooled to $T < 1$ Kelvin
  - 1 degree above absolute zero temperature.
- Qubits are manmade + need to be tuned.
- Fixed qubit wiring

Trapped Ions:

Effective spring-like interaction

Qubit: - Atomic energy level (valence electron)

Connection: - Motion between ions
- Turned on and off with laser beams.

Advantages: - Long (coherence (storage) times
- All qubits are identical
- Highest fidelity operations

Disadvantages: - slow Gates
- scalability is difficult