Building a Quantum Computer

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Motivation

- Ever-increasing need for fast computers

Difference Between Quantum and Classical computation

- Number of informational states in a quantum and classical bit

- 2-bit classical (2x1 possible states)
  2-qubits (2x2 possible states)

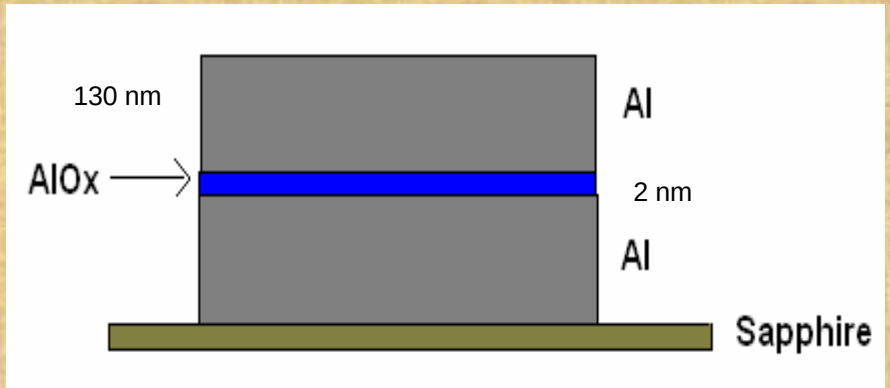
- A 32-bit quantum processor could be as powerful as 4 billion Pentium 4's

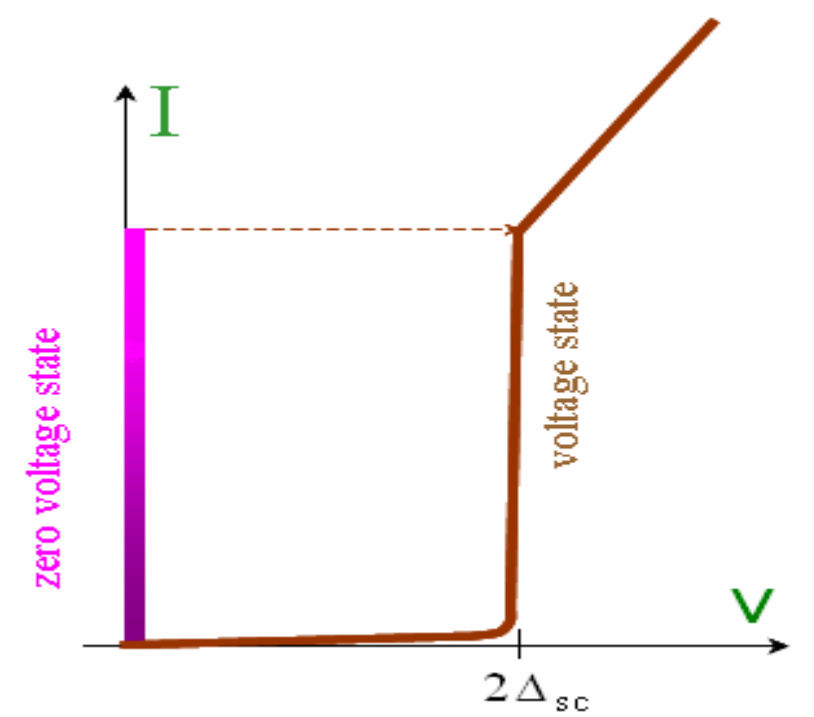
Applications:

- Powerful decryption tool and could break even most secured encryption used today
- Search engines much faster than Google by using fewer computers
- Could solve many complex problems in a reasonable amount of time

Technique:

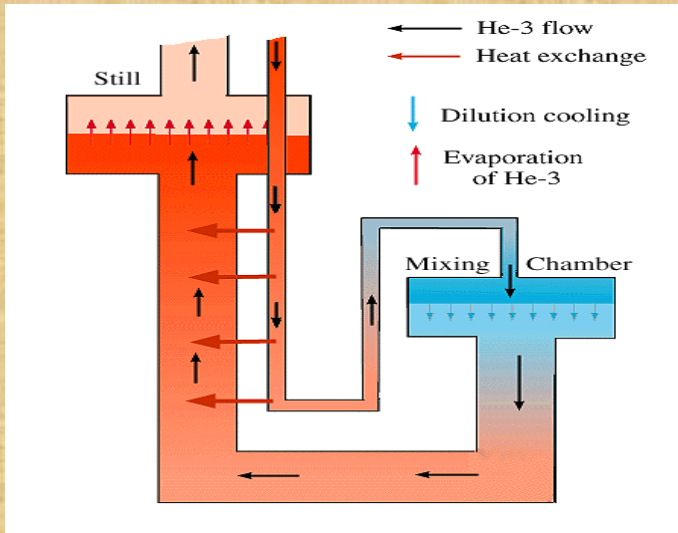
Use of superconducting Josephson junction to build a quantum bit (Qubit)





Dilution Refrigerator:

- Phase separation of ^{3}He and ^{4}He Mixture below 1 K.



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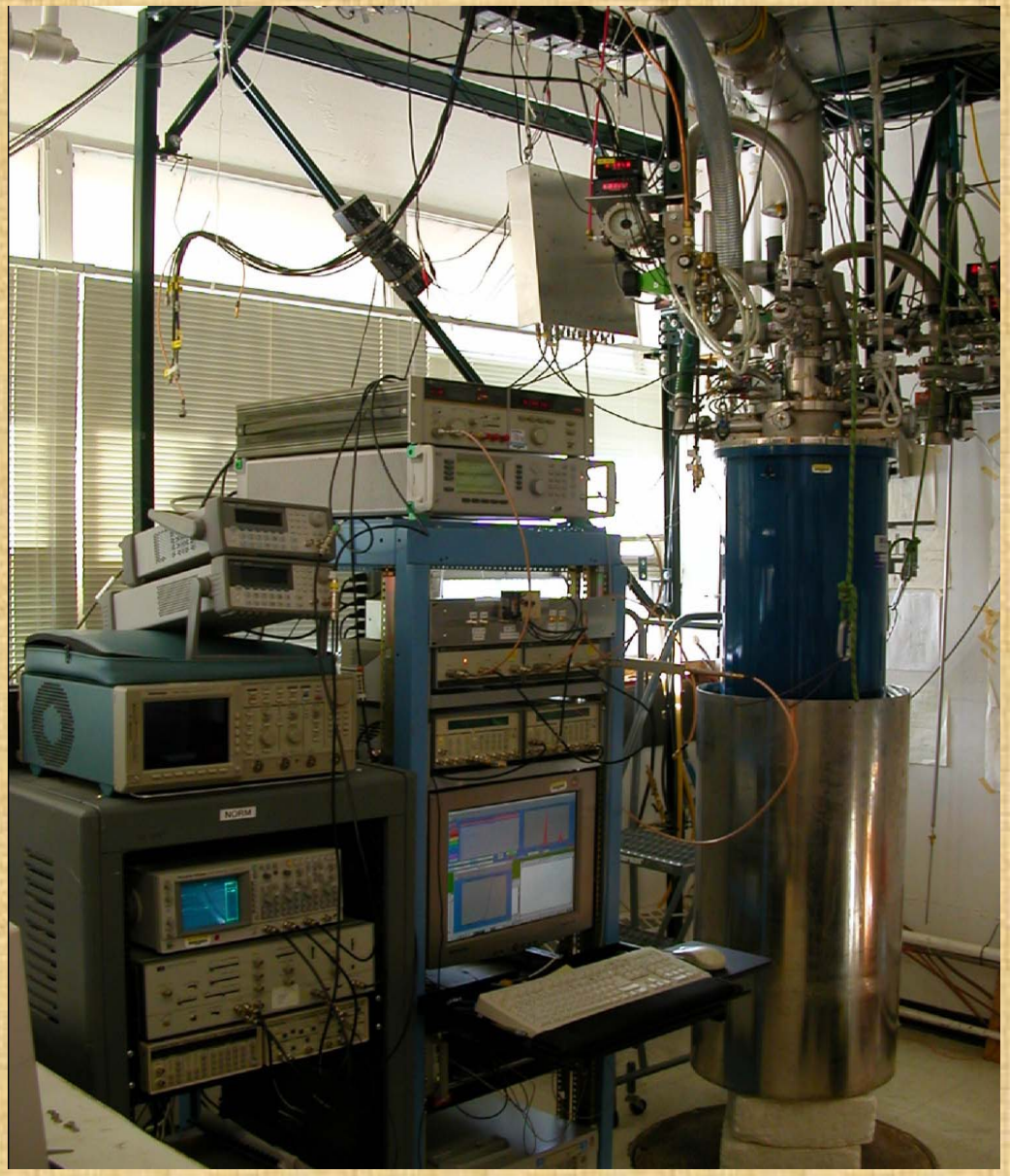
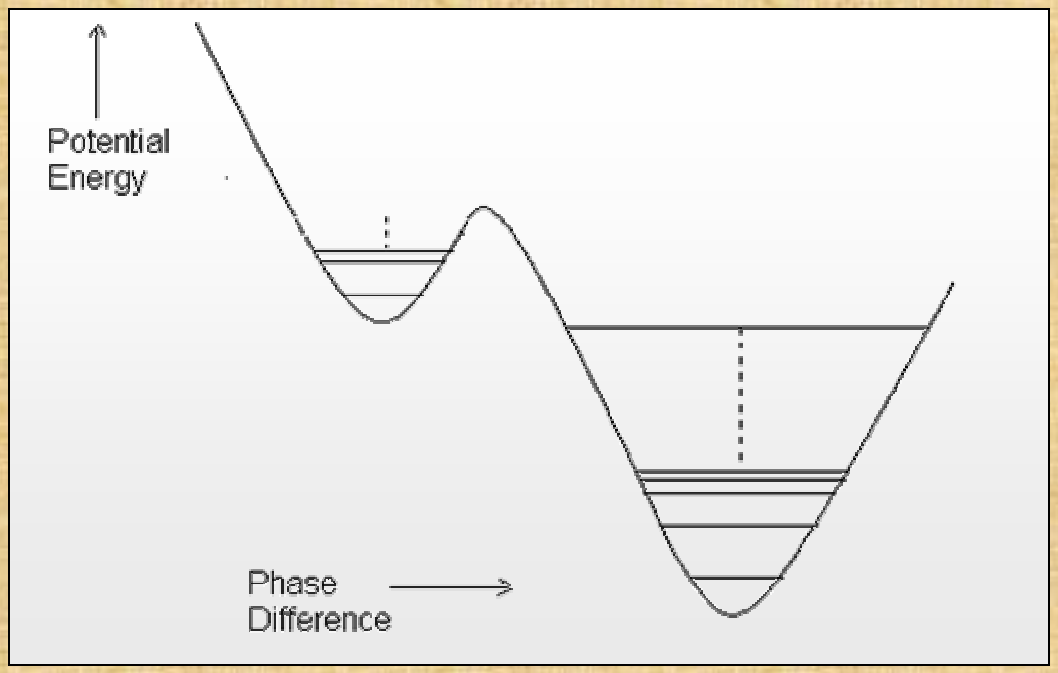
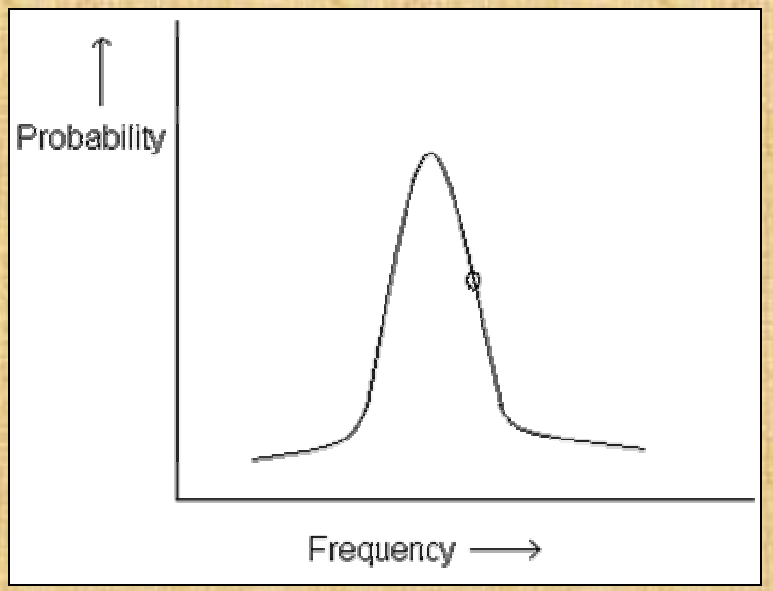


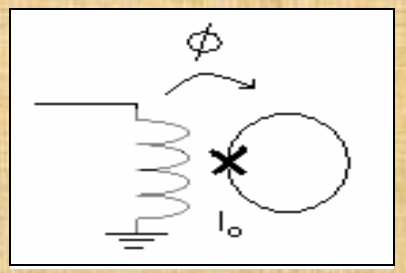
- ^{3}He is pumped out from the ^{4}He rich phase
- For equilibrium some ^{3}He has to move across the phase boundary
- ^{3}He is pumped back and constantly circulated

Plan:

- Build an artificial atom
- Use lowest two energy states to represent binary numbers: 0 and 1
- Use microwave pulses to switch between energy states





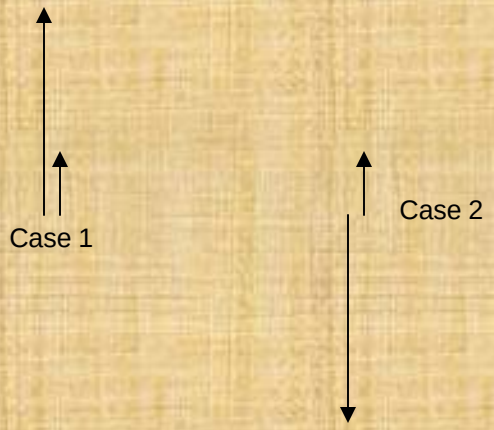


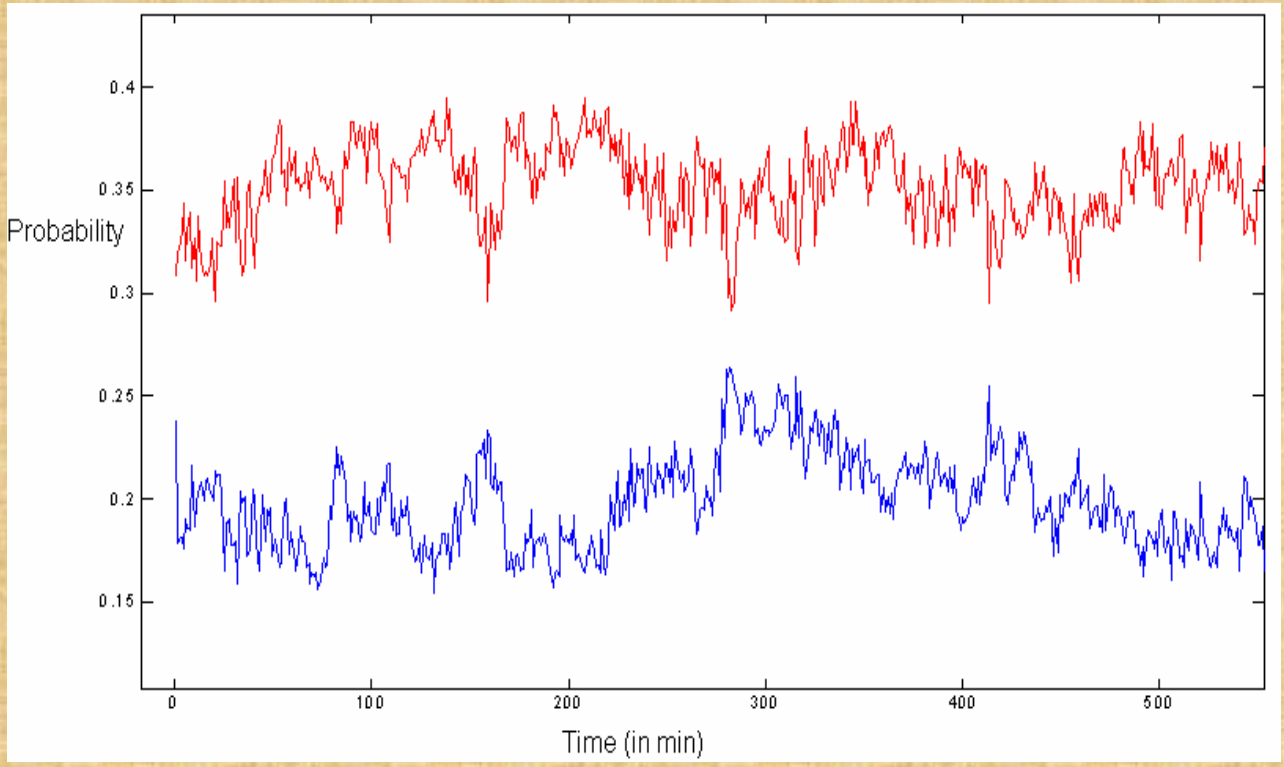
Obstacles:

- Phase De-coherence due to critical current or magnetic flux noise

Critical Current noise or Magnetic flux noise?

- Resonant frequency depends on the amount of magnetic flux through the qubit
- Operation of the qubit close to the resonant frequency at opposite flux bias
- Different behavior of the noises towards magnetic flux bias

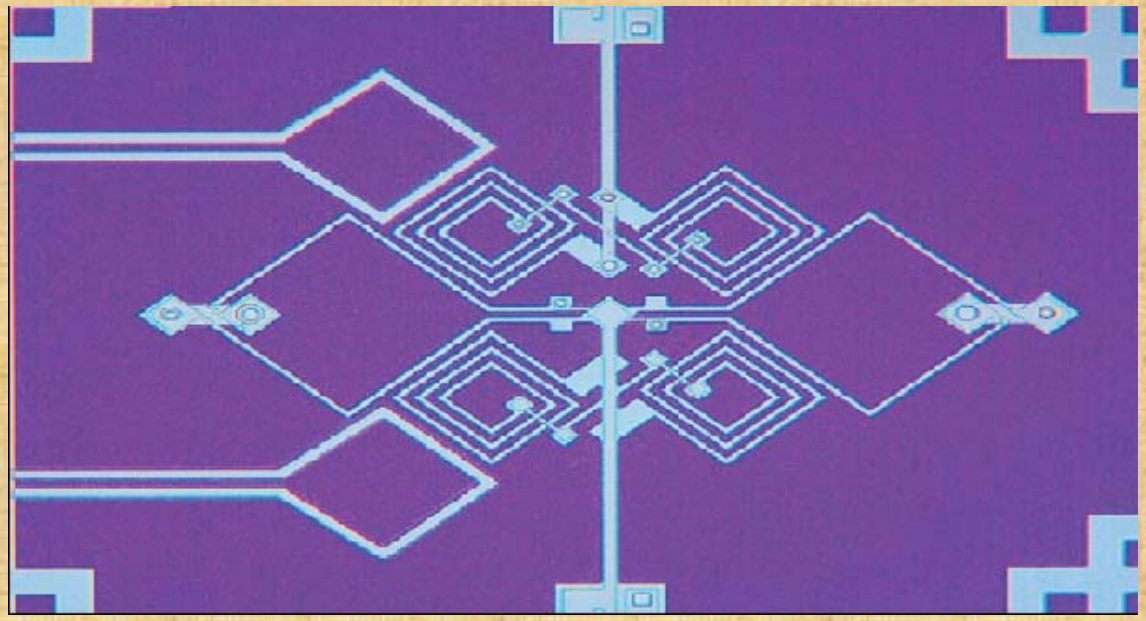




Courtesy of Martinis group UCSB

Future Modifications

- Making wires as thin as possible
- Better materials for the junction to increase the coherence time



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What did I learn?

- How a formal research works?
- Got introduced to cryogenic electronics and materials
- Got my hands on important electronic equipment and got exposed to formal data keeping
- Learnt basics of quantum computing
- Learnt to design and make printed circuit boards
- Learnt computer programs such as lab view which are used for data acquisition
- Learnt how important undergraduate research is.