Week 11: Quantum Hardware

For Physics and Chemistry students

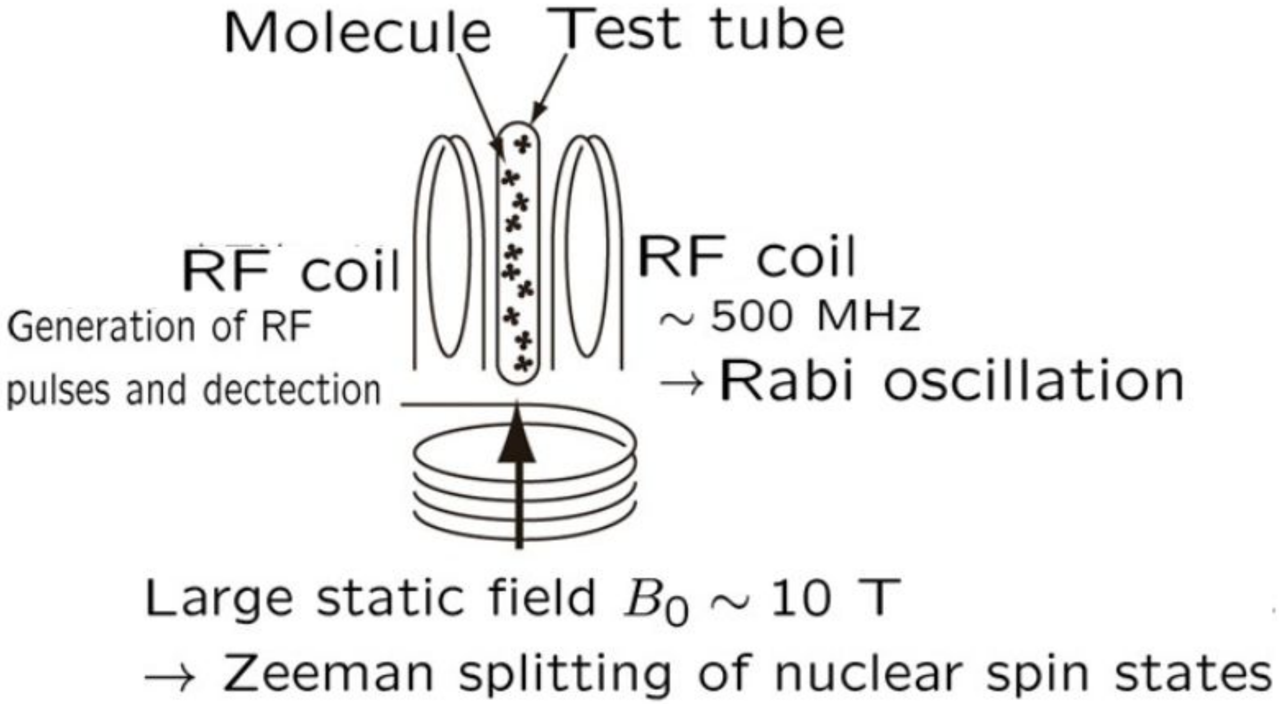
Various QC Technologies

In this module, we will study various QC Technologies like NMR, Superconducting QC and Trapped Ions Quantum Computing

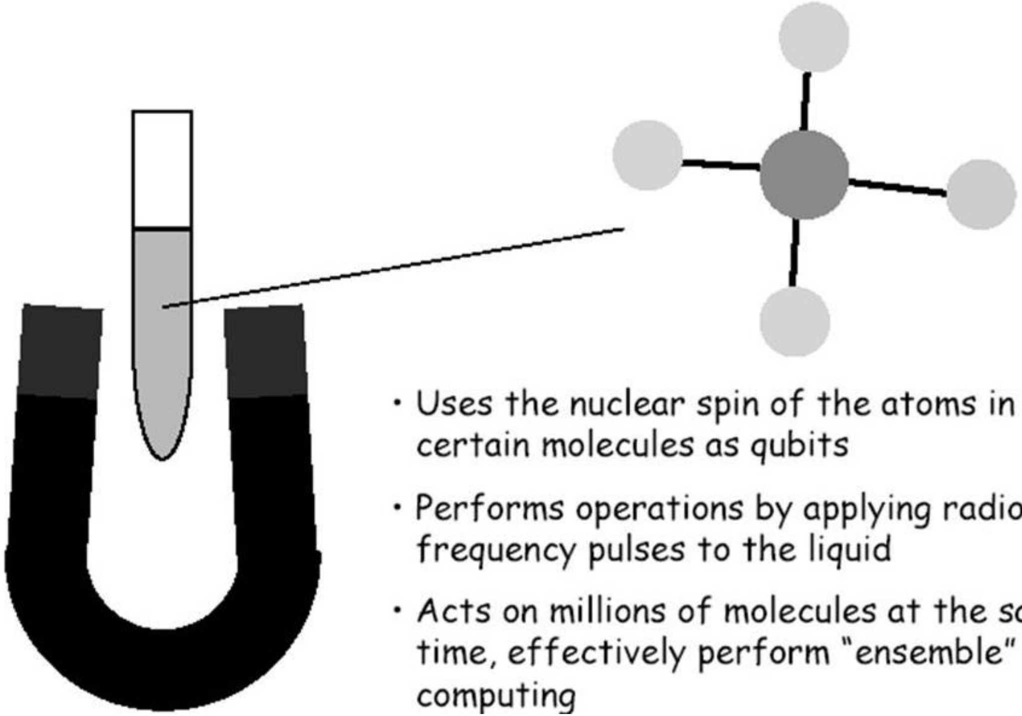
DiVincenzo Criteria

- A scalable physical system with well characterized qubit
- The ability to initialize the state of the qubits to a simple fiducial state
- Long relevant decoherence times
- A "universal" set of quantum gates
- A qubit-specific measurement capability

Nuclear Magnetic Resonance QC

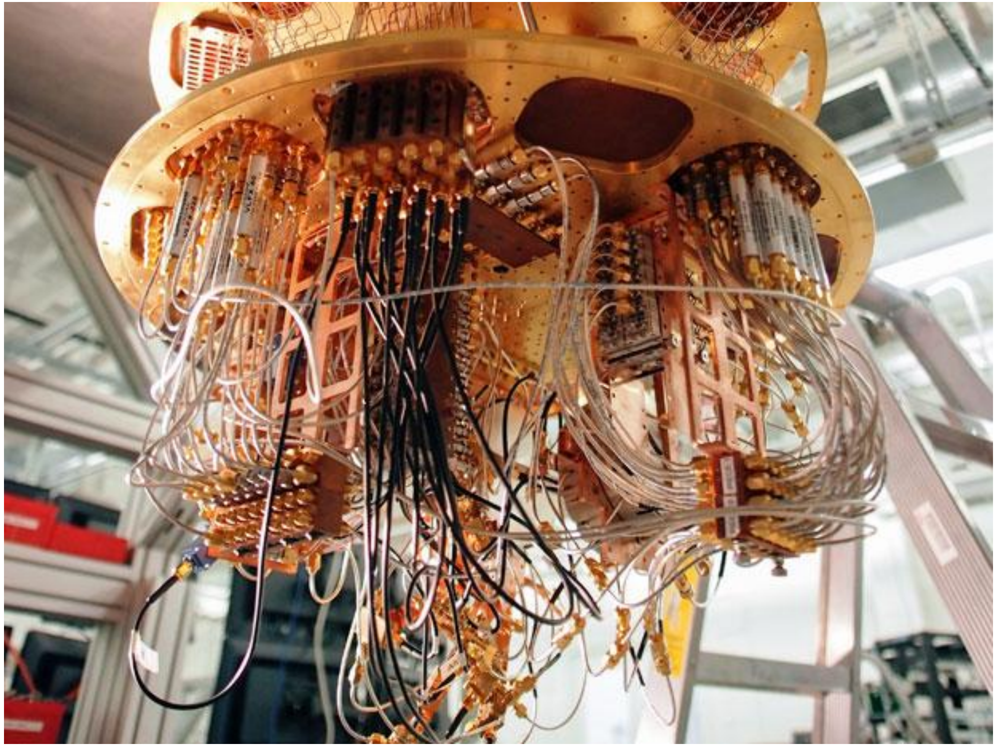


Nuclear Magnetic Resonance QC



- Uses the nuclear spin of the atoms in certain molecules as qubits
- Performs operations by applying radio-frequency pulses to the liquid
- Acts on millions of molecules at the same time, effectively perform "ensemble" computing

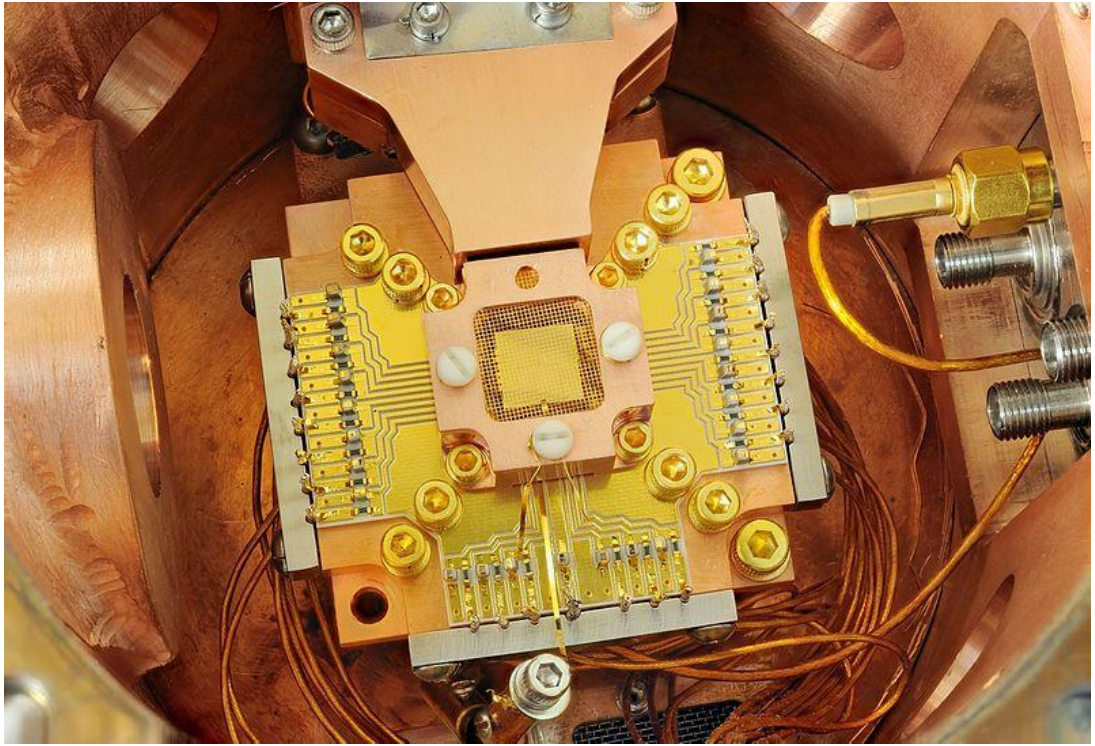
Superconducting QC



Superconducting QC

- Provides with 3 qubit architectures i.e. charge, flux and phase qubits.
- Scalable and easy to fabricate
- Based on the concept of superconducting electrons (Electron-Electron pairing), it makes use of Josephson Junctions.
- We need refrigeration for this QC technology and the qubits are immobile.

Trapped Ion Quantum Computing



Trapped Ion QC

- Hyperfine qubits vs. Optical Qubits
- Hyperfine qubits are better than optical qubits in the sense that they are insensitive to magnetic perturbations, stable and the superposition lasts for minutes in certain cases. However, ion traps in general face controlling issues and are not that scalable since using a string of ions to act as qubits and performing high-fidelity operations on them is very hard. Switching is difficult to implement.

Mathematical Rigor in handout and on board