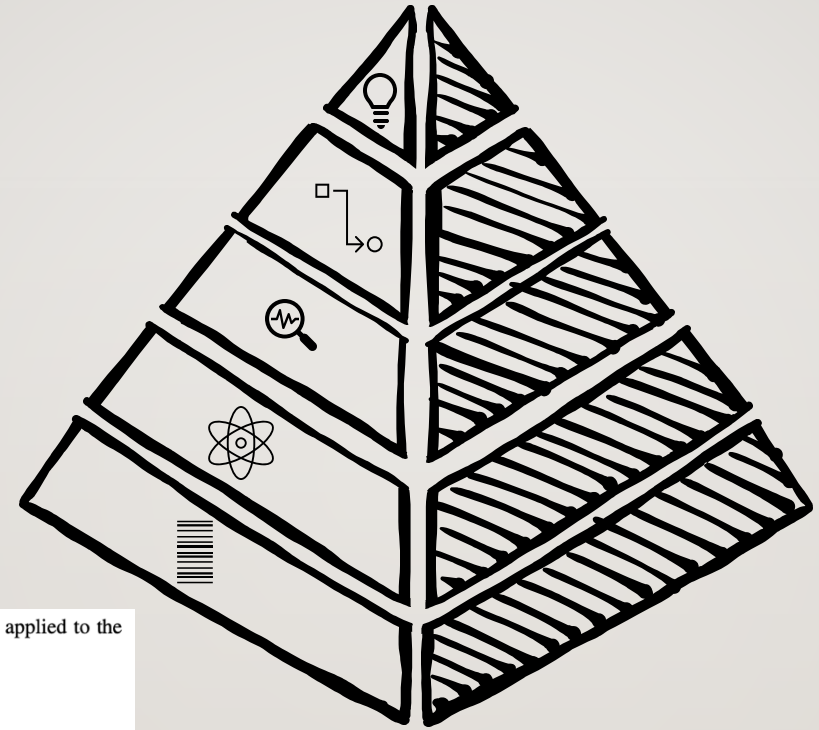
EE337 PJ Trapped-ion Quantum Computer : From Ion Trapping to Gate Implementation

QUANTUM INFO

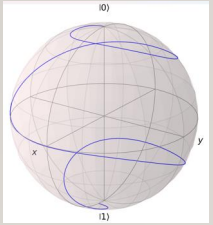
We assume in class that there is a qubit, but what is happening under the hood in a trapped ion quantum computer?



GATE

1. Sinlgle-qubit gates
➔ Shooting laser pulse to trapped ion
➔ From the dipole interaction between the atom's electric dipole and the electric field in the laser you applied.

2. Two-qubit gates
➔ Apply each pulse to ion A and ion B.

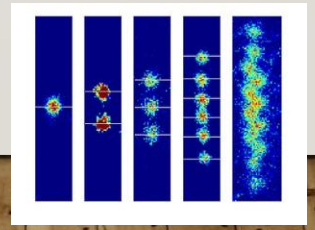


Following are all the cases for $|AB\ \text{Phonon}\rangle$ applied to the CZ gate:

$$|gg0\rangle \to |gg0\rangle \to |gg0\rangle \to |gg0\rangle$$
$$|ge0\rangle \to |ge0\rangle \to |ge0\rangle \to |ge0\rangle$$
$$|eg0\rangle \to -i|gg1\rangle \to i|gg1\rangle \to |eg0\rangle$$
$$|ee0\rangle \to -i|ge1\rangle \to i|ge1\rangle \to |ee0\rangle$$

ADVANTAGE OF TAPPED ION QUANTUM COMPUTER

Each ion can interact with every other ion directly
➔ All-to-all connectivity
➔ Efficient in performing multi-qubit operations w/o swapping the qubits.



Cf. Superconducting qubit
➔ Interactions are limited to neighboring qubits in the grid.

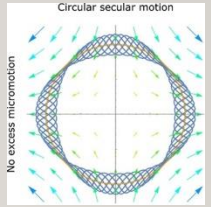
QUBIT

1. Initialization
➔ Add Cooling Laser.
➔ Pump and Decay to |0>.

2. Measurement
➔ Add Cooling Laser
1) If |0> : nothing.
2) If |1> : photon emission.

ION TRAPPING

Static and oscillating electric fileds
➔ Confine ions



HYPER FINE STRUCTURE

<When the atom becomes ion>
the interaction between the magnetic monents arising from the spins of both the nucleus and electrons in atoms
➔ Split of energy levels.

The angular momentum and quantum #
➔ State representation of qubit.

$$|0\rangle \Leftrightarrow {}^2S_{1/2}, F = 0$$
$$|1\rangle \Leftrightarrow {}^2S_{1/2}, F = 1$$

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