Quantum Computation and Information

A Gentle Introduction

Pedro Rivero

Argonne National Laboratory
Illinois Institute of Technology
priveroramirez@anl.gov

October 21, 2019

Contents Overview

What is Quantum Computing?

Quantum Computing is the application of **Quantum Information Science (QIS)** to the development of *machines* capable of performing calculations based on quantum logic instead of the well know classical logic. It is thought to be fundamentally different and much more powerful.

The usefulness of this kind of computation lays not only on the ability to engineer exponentially faster machines, but also on being able to create encryption systems which are fundamentally safe, and **simulating nature at the atomic** level for game-changing purposes.

CLASSICAL LOGIC
Set Theory (Boolean algebra)

- **AND** $\Rightarrow$ $A \cup B$
- **OR** $\Rightarrow$ $A \cap B$
- **NOT** $\Rightarrow$ $\overline{A}$
- **XOR** $\Rightarrow$ $A \cap B - A \cup B$

QUANTUM LOGIC
Quantum Theory (Non-Commutative)

- Probabilistic measurement
- Measurement causes disturbance
- Superposition
- Entanglement
- Uncertainty principle

The Abacus Effect

Quantum Software: IBM's Qiskit

Analog VS Digital

References

"The only thing demonstrated by an impossibility proof is a lack of imagination."
– John Stewart Bell –


Argonne
NATIONAL LABORATORY