Lecture1 part 2

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1 Introduction

- Quantum computing - "Natural generalization of computing".
- Quantum computers are computers that obey quantum physics.

1.1 Why quantum computing?

- Extended Church Turing Thesis (ECT): Any algorithmic process can be efficiently simulated by a probabilistic Turing machine.
- David Deutsch:-Is there a physical model of computation that violates ECT?
- Computation devices built using the principles of quantum physics can offer a stronger version to their thesis.
- Do quantum computers that obey quantum mechanics violate ECT?
- Feynman asks if we can simulate quantum physics on a classical computer.
- Number of variables to keep track of is exponential in the size of the quantum system. For example, for a 100 electron system,2^{100} bits are needed in comparison to 100 qubits.

2 Quantum computing in the circuit model (Postulates of Quantum mechanics in action)

2.1 State Preparation

- Prepare the quantum computer in a given initial state
$|\psi_0\rangle = |0\rangle^{\otimes n}$
- $|0\rangle = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$
$|0\rangle \otimes |0\rangle = |0\rangle^{\otimes 2} = |0\rangle|0\rangle = |00\rangle$

2.2 Evolution

- Schrodinger's equation :

  $i\frac{d|\psi\rangle}{dt}=H|\psi\rangle$

  $|\psi(t)\rangle=e^{-iHt}|\psi(0)\rangle$

- H: Hamiltonian observable for energy

- $u_t=e^{-iHt}$

- The initial state $|\psi_0\rangle$ evolves based on a series of unitary operators
  $|\psi_f\rangle=u_t u_{t-1} u_{t-2}...u_2 u_1|\psi_0\rangle$
  where each u_i is a quantum gate

2.3 Measurement

- Measure the final state in the computational basis: M=$|j\rangle\langle j|$ where $j \in \{0,1\}^n$

- Observe $|f\rangle$ with probability p such that:
  $p = |\langle f|\psi_f\rangle|^2$