Quantum Photonics

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Quantum

Leverages:
- Entanglement: Correlation between quantum states.
- Superposition: the ability of a quantum system to be in multiple states at the same time.
- Interference: positive and negative probability amplitudes

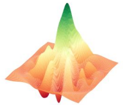
Computes by narrowing down superposition of entangled states and using probability interference

Why Photonics?

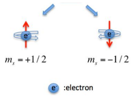
- Room Temperature
- Manufacturable with silicon
- Can be made into small components

Qubits & Qumodes

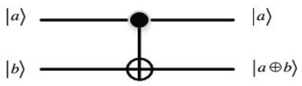
Qumodes: Continuous variable (photonics)



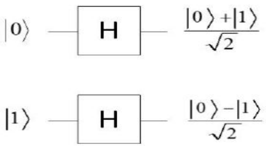
Qubits: Discrete variable (Super Conducting)



Quantum Gates



CNOT gate

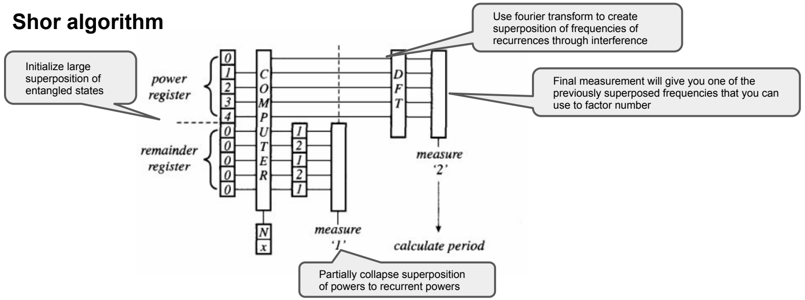


Hadamard gate

CNOT gate creates entanglement of quantum states, and the hadamard gate creates a superposition of states.

Quantum Algorithms

Shor algorithm



Other quantum algorithms can be carried out similarly, where we create a large superposition of potential answers and "narrow down" that superposition by partially collapsing (measure 1) or using probability interference (DFT) until a final measurement will yield a useful result.

Grover's algorithm can search through a superposition of states and increase the probability of finding a state that we search for while decreasing the probability of other states. This can be very useful for machine learning applications in training networks

Companies in Quantum Photonics

- Xanadu (StrawberryFields, PennyLane)
- PsiQuantum
- ORCA computing

Applications

- Machine Learning
- Quantum Simulation
- Graph Similarity
- Problems in NP
- Quantum Cryptography

Limitations of Quantum Photonics

- Quantum Memory - rapid decoherence in photons makes state preservation difficult
- Physical Implementations of Gates - certain gates require specific nonlinear interactions to occur. Current materials don't have strong enough interaction to create these. Other methods through linear gates have been proposed but they come with their own issues
- Initialization - getting large sets of initialized to |0> entangled states is also difficult due to decoherence