Benchmarking a Neutral Atom Quantum Computer

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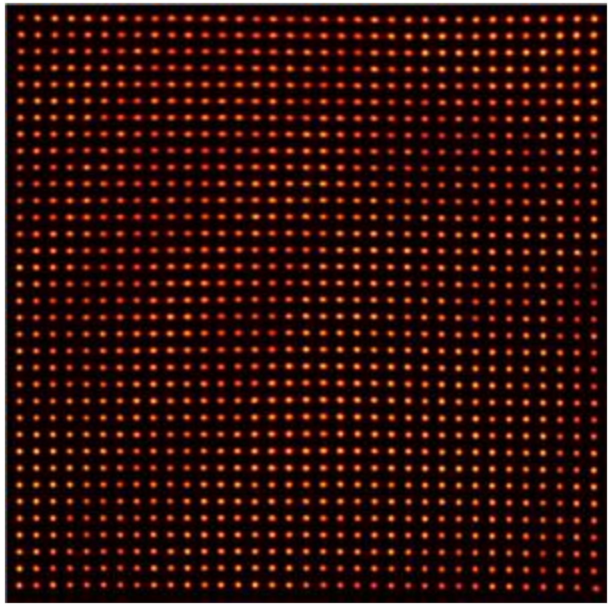
Neutral Atom Quantum Computing



Cesium Atoms Loaded Onto Our Laboratory's Optical Lattice

- Analogously to how computers store information in bits, quantum computers store information in qubits
- One major challenge in quantum computing is choosing the best physical realization of a qubit
- Several candidates have been proposed, and many of the leading quantum computers currently use different hardware
- Our group uses neutral ultracold cesium atoms in an optical lattice

Why Neutral Atoms?

- Entanglement is ultimately what makes quantum computers much more powerful than classical computers
- However, entanglement is restricted to specific pairs of qubits
- The degree to which qubits can be entangled is called the computer's connectivity
- One of the advantages of neutral-atom quantum computers is the large distance between which two qubits can be entangled

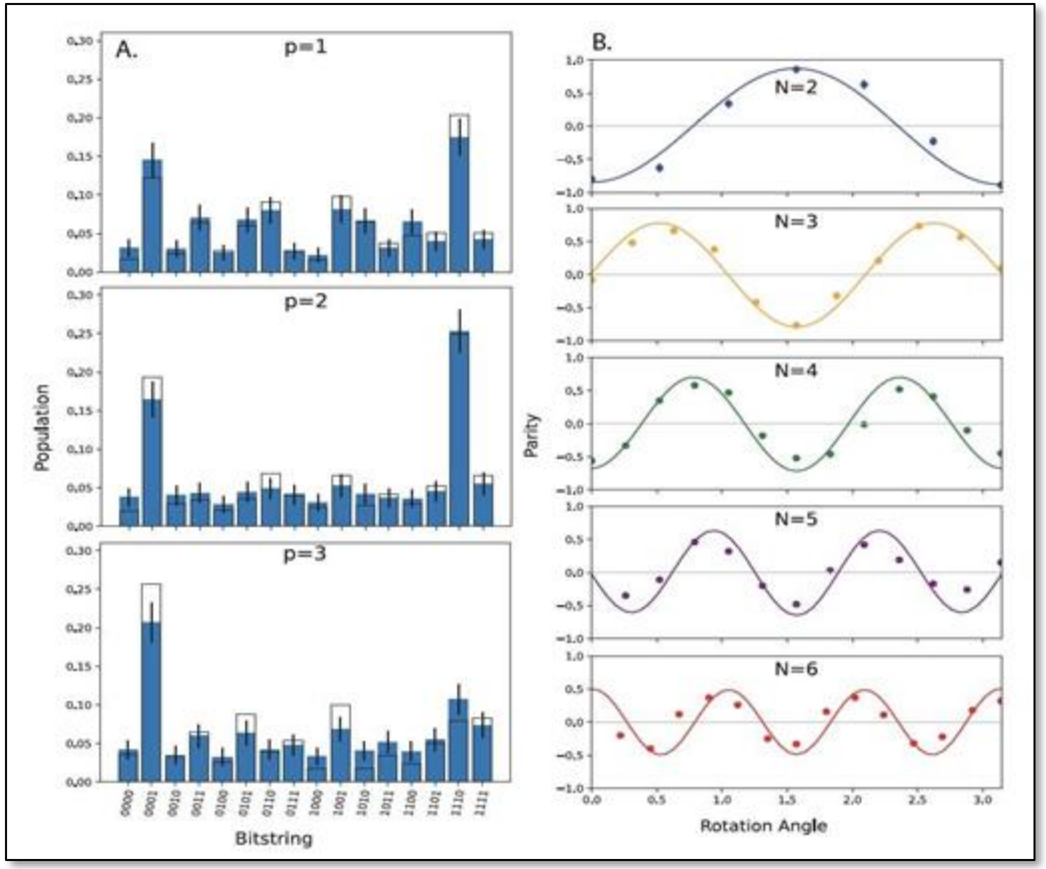
All-to-All vs. Nearest Neighbor Connectivity

Methods

- My work aims to demonstrate the extent to which improved connectivity helps performance

- To do this, we developed a noise model which accurately predicts the behavior of our group's quantum computer

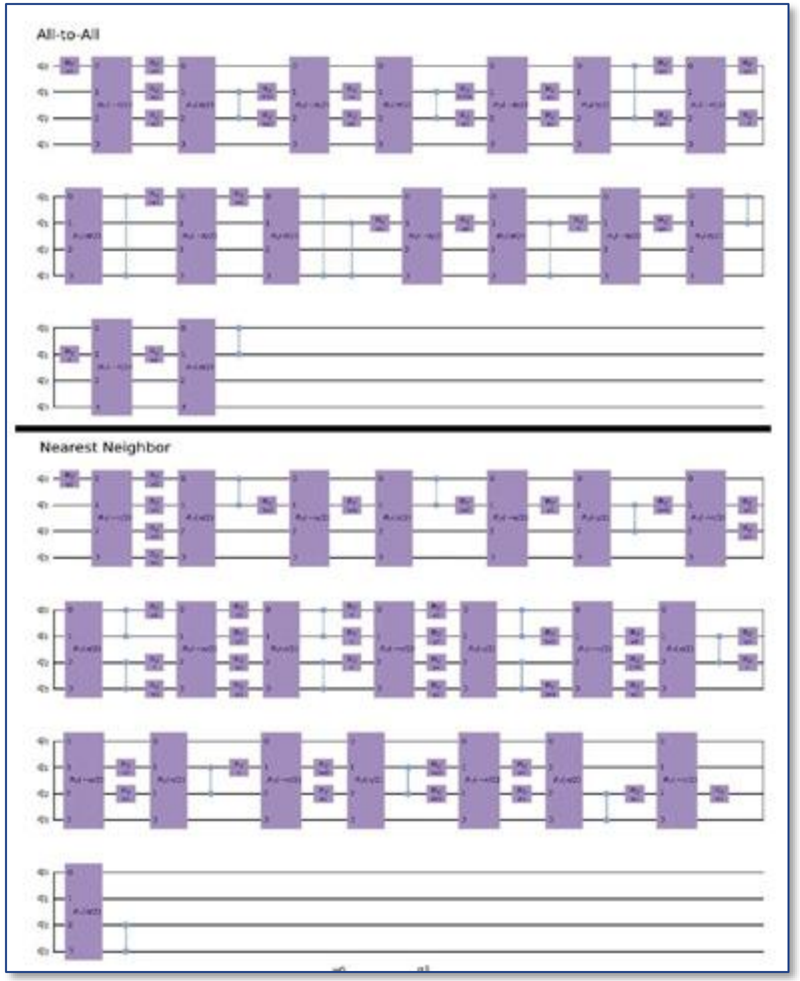
- Doing this helps us understand the degree to which certain sources affect our computer, and quickly predict the results of experiments



Comparison of Simulated and Experimental Data

Methods

- We assessed the performance of the computer under the best and worst-case connectivities using an application-oriented benchmark
- An application-oriented benchmark enables us to directly measure how well our computer performs using practical circuits
- Some examples of circuits included in the benchmark are the quantum Fourier Transform and phase estimation, both of which are important subroutines in practice



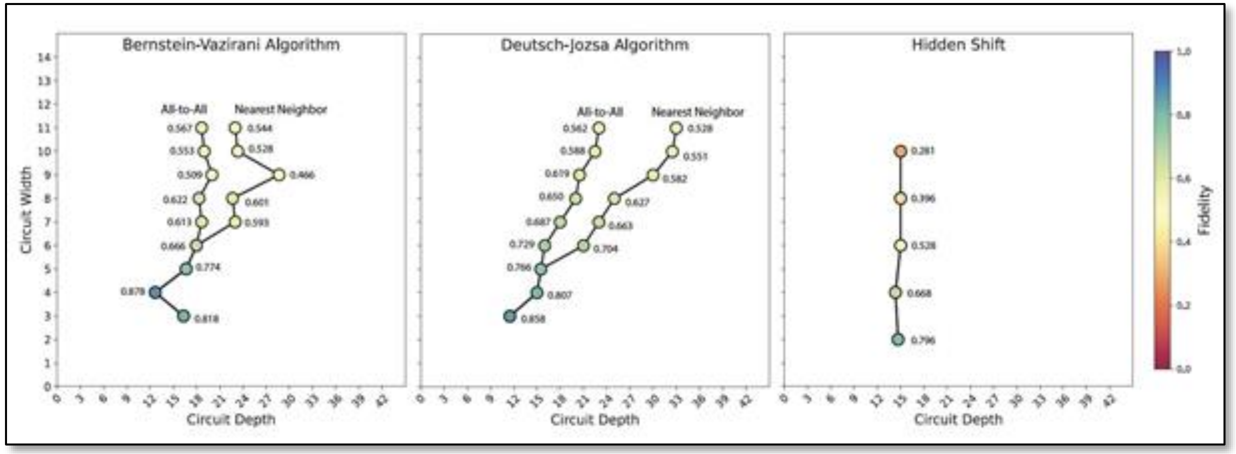
Two Implementations of the Same Algorithm with Different Connectivities

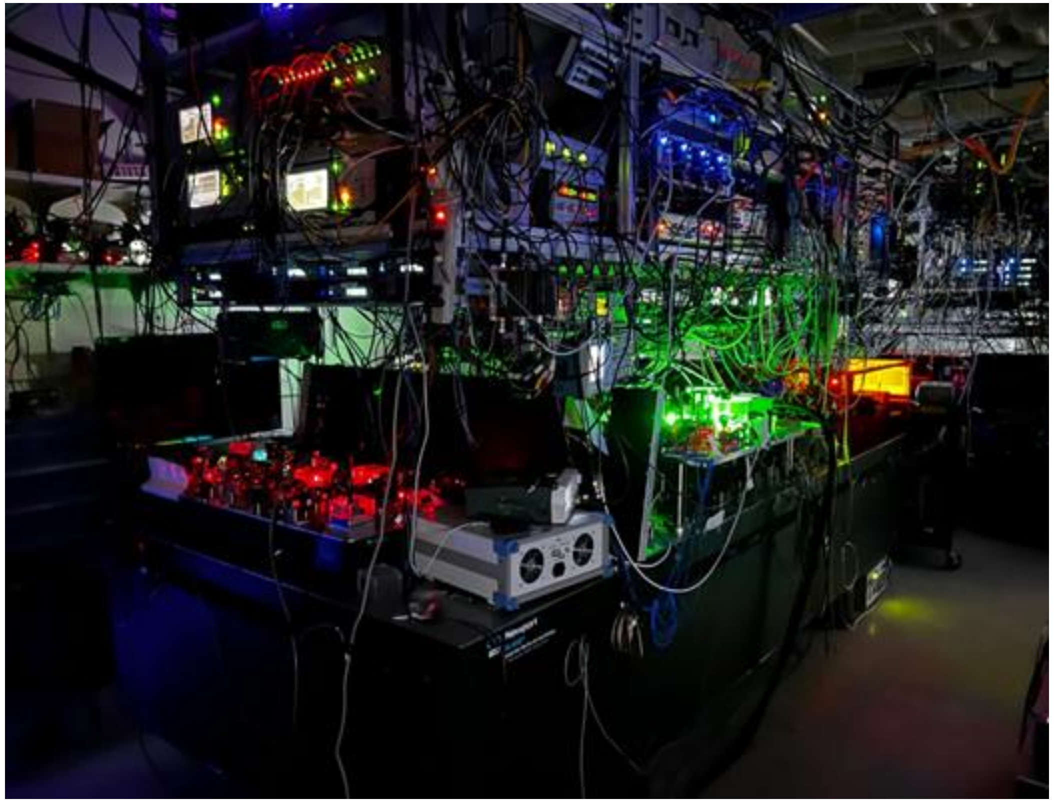
Results

- All-to-all connectivity can improve the fidelity o offer 10-15% better data fidelity versus nearest-neighbor connectivities

- Inverse Quantum Fourier Transform fidelity increased by 13% within the 3-5 qubit range, peaking at 17% increase using a five-qubit implementation

- Next Steps For Research: Optimizing laser traps and additional qubit scalability studies





Saffman Group's quantum computer

Questions?

Thank You

Feb 2024 manuscript In *International Journal of Quantum Information*

Additional credits and references provided.