Type II Quantum Computing Using Superconducting Qubits

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Sponsorship

Most algorithms designed for quantum computers will not best their classical counterparts until they are implemented with thousands of qubits. By all measures this technology is far in the future. On the other hand, the factorized quantum lattice-gas algorithm (FQLGA) can be implemented on a type II quantum computer, where its speedups are realizable with qubits numbering only in the teens. The FQLGA uses a type II architecture, where an array of nodes, with only a small number of coherently coupled qubits is connected classically (incoherently). It is the small number of coupled qubits that will allow this algorithm to be of the first practical quantum algorithms implemented.

The algorithm is the quantum mechanical version of the classical lattice gas algorithm, which can simulate the Navier-Stokes equation with unconditional stability. This algorithm was developed in the 1980's and has been a powerful fluid dynamic simulation model ever since. It is a bottom-up model where the microdynamics are governed by only three sets of rules, unrelated to the microscopic physics of the system. The quantum algorithm has all the properties of the classical algorithm but with an exponential speedup in running time.

We are currently looking into the feasibility of implementing this algorithm with our superconducting qubits, with long-term plans of constructing a simple type II quantum computer. A few of the questions currently being addressed are the following:

With what accuracy can our qubits be set into a specific quantum state while coupled to other qubits and measurement devices? This will be the limiting factor in the accuracy of our fluid simulations. Since ensemble measurements are performed in the algorithm, should these repeated measurements be performed repeatedly in time or in space? Can we design our system so that the qubits' Hamiltonian will force them to evolve the same as they would under the specified unitary transformation for the algorithm? This would give the quantum algorithm its speedup.