DAMOP17-2017-020114

Abstract for an Invited Paper
for the DAMOP17 Meeting of
the American Physical Society

A programmable five qubit quantum computer using trapped atomic ions

SHANTANU DEBNATH, Joint Quantum Institute, University of Maryland - College Park

In order to harness the power of quantum information processing, several candidate systems have been investigated, and tailored to demonstrate only specific computations. In my thesis work, we construct a general-purpose multi-qubit device using a linear chain of trapped ion qubits, which in principle can be programmed to run any quantum algorithm. To achieve such flexibility, we develop a pulse shaping technique to realize a set of fully connected two-qubit rotations that entangle arbitrary pairs of qubits using multiple motional modes of the chain. Following a computation architecture, such highly expressive two-qubit gates along with arbitrary single-qubit rotations can be used to compile modular universal logic gates that are effected by targeted optical fields and hence can be reconfigured according to any algorithm circuit programmed in the software. As a demonstration, we run the Deutsch-Jozsa and Bernstein-Vazirani algorithm, and a fully coherent quantum Fourier transform, that we use to solve the 'period finding' and 'quantum phase estimation' problem. Combining these results with recent demonstrations of quantum fault-tolerance, Grover's search algorithm, and simulation of boson hopping establishes the versatility of such a computation module that can potentially be connected to other modules for future large-scale computations.