High-fidelity Quantum and Classical Control in Microfabricated Surface Ion Traps

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Trapped ions are among the top candidates for realizing high fidelity gate operations for quantum computation as well as other applications including quantum simulation and sensing [1]. However, scaling these systems up to the number of qubits required to solve interesting problems with conventional macroscopic traps quickly becomes intractable. To overcome the scalability challenge, advanced microfabrication techniques have been developed to support a variety of complex electrode layouts, allowing for precise and dynamic control of confining potentials.

Using Sandia's microfabricated surface ion traps, which feature low heating rates, high trap frequencies, and long trapping times, we demonstrate novel classical control techniques that employ parametric voltage solutions for elegant composition of shuttling operations and accurate control over the curvature of the confining potential. To demonstrate the viability of Sandia's microfabricated ion traps for quantum information processing, we've realized of high-fidelity single-qubit gates below a rigorous fault tolerance threshold for general noise [2,3] and two-qubit Mølmer-Sørensen gates with a process fidelity of 99.58(6)%.

[1] N.M. Linke et al. Proc. Natl. Acad. Sci. 114, 13 (2017)
[2] R. Blume-Kohout et al. arXiv:1606.07674
[3] P. Aliferis and J. Preskill, Phys. Rev. A 79, 012332 (2009)