Scalable, high-fidelity all-electronic control of trapped-ion qubits

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The central challenge of quantum computing is implementing high-fidelity quantum gates in a scalable fashion. Our all-electronic qubit control architecture combines laser-free gates with local tuning of electric potentials to enable site-selective single- and two-qubit operations in multi-zone quantum processors. Chip-integrated antennas deliver control fields common to all qubits, while voltages applied to local tuning electrodes adjust the position and motion of ions in each zone, thus enabling local coherent control. We experimentally implement low-noise, site-selective single- and two-qubit control in a microfabricated 7-zone ion trap, demonstrating 99.99916(7)% fidelity for single-qubit gates, and two-qubit Bell state generation with 99.97(1)% fidelity. These results validate the path to directly scaling these techniques to large-scale quantum computers based on electronically controlled trapped-ion qubits[1].

References

[1] https://arxiv.org/abs/2407.07694

Figures

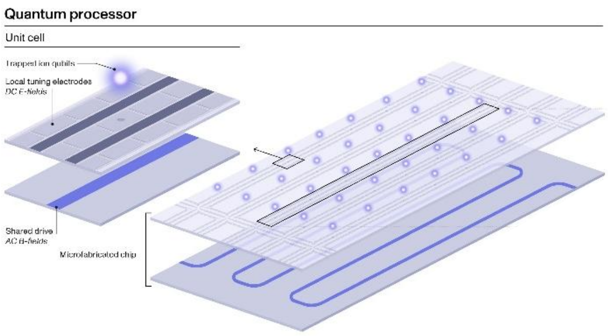

Figure 1: Illustration of the all-electronic approach to the coherent control of trapped-ion qubits. The TIQC is a microfabricated chip (right) that contains a repeating 2D grid of unit cells (left), each composed of trapped-ion qubits stored near local tuning electrodes. A shared drive is routed to deliver AC magnetic fields to all unit cells at once. The strength of qubit coupling with the shared drive is controlled by applying DC electric fields to the tuning electrodes.