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A modular approach to a shuttling-based quantum processor in a 2D trap array

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Trapped ion qubits achieve excellent coherence times and gate fidelities, well below the threshold for fault tolerant quantum error correction. A key challenge now is to scale ion quantum processors to the large number of qubits required for error-corrected algorithms to run. We present progress on the implementation of high fidelity ion qubits in a modular architecture designed for true scalability, based on robust microwave-driven quantum gates and physical shuttling of ion qubits. [1]

We describe an X-junction surface ion trap, made using industrial silicon microfabrication techniques. The multi-arm geometry permits dedicated operational zones, optimised for ion loading, memory, entangling interactions and readout, and also permits 2-dimensional ion transport as required by the surface code error-correction scheme. [2]

Qubits are defined in the internal hyperfine states of the 171Yb+ ion. We utilise different qubit representations within the four natural spin states defined by the electron and nuclear spins, performing readout based on natural state dependent fluorescence and also dressing the states to engineer an artificial clock-like qubit less sensitive to environmental noise. [3]

Entanglement is generated by modulating the Coulomb interaction between ion pairs in a strong magnetic field gradient. Driving the spin-motion entangling (Molmer-Sorenen) gate directly with global AC magnetic fields rather than using locally focussed laser excitation relives much of the complexity in laser engineering found in traditional ion trap processors based on optical transitions. [4]

We outline progress in dynamically generating the strong magnetic field gradients used for entanglement generation, using switchable currents through microfabricated coils embedded locally within the trap substrate. This integrated strategy facilitates ion transport within our architecture despite strong field gradients, but also necessitates careful management of the heat dissipated on-chip.

Our modular architecture deliberately avoids photonic interconnects, and instead takes advantage of the inherent mobility of trapped-ion qubits to achieve the large-scale entanglement required for fault-tolerant quantum computing.

[1] Lekitsch, B. et al. Blueprint for a microwave trapped ion quantum computer. Science Advances, 3:2, (2017).
[2] Fowler, A.G. et al. Surface codes: Towards practical large-scale quantum computation. Phys. Rev. A 86:032324, (2012).
[3] Webster, S.C. et al. Simple manipulation of a microwave dressed-state ion qubit. Phys. Rev. Lett., 111:140501, (2013).
[4] Weidt, S. et al. Trapped-ion quantum logic with global radiation fields. Phys. Rev. Lett., 117:220501, (2016).

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