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Demonstration of a universal two-qubit register for a QCCD-based quantum processor

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Single-qubit rotations and a two-qubit entangling gate form a universal set of quantum logic gates[1]. In this work, we realize such a two-qubit computational register that is compatible with the quantum charge-coupled device (QCCD) architecture. Quantum logic operations are implemented using embedded microwave conductors. Single-qubit gates in two-ion crystals are performed by addressing each ion individually with a micromotion addressing technique[2]. The single-qubit gate infidelity of individually addressed ion is characterized using a randomized benchmark protocol of $3.8(4)\times10^{-3}$. The entanglement operation is implemented using a Mølmer-Sørensen type interaction, where we measure an infidelity approaching 10^{-3} using partial state tomography[3]. Finally, we characterize the quantum processor in a computational context using the cycle benchmarking protocol[4]. We present a partial analysis of the discrepancy of the above results.

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[4] A. Erhard *et al.*, Nat. Commun. **10**, 5347 (2019)

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