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Deterministic Quantum Gate Teleportation across a Trapped-Ion Quantum Network

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Quantum gate teleportation utilises shared entanglement and local operations and classical communication to mediate logical gate operations between qubits that cannot directly interact, making it an essential tool for the modular quantum computing architecture [1]. In this work, we demonstrate the deterministic teleportation of a controlled-Z gate between two $^{43}Ca^{+}$ hyperfine clock qubits located in separated trapped-ion quantum processors, measuring an average gate fidelity of 86.2(8) %. We achieve this by combining state-of-the-art remote entanglement between two $^{88}Sr^{+}$ network ions [2] and local mixed-species entangling gates to mediate an interaction between co-trapped $^{43}Ca^{+}$ memory ions [3]. We discuss how this system enables distribution of a circuit comprising multiple instances of gate teleportation across our quantum network. Our results pave the way for distributed quantum computation based on networks of trapped-ion quantum processors.

[1] D. Gottesman, I. Chuang, Demonstrating the viability of universal quantum computation using teleportation and single-qubit operations. Nature 402, 390–393 (1999).

[2] L. Stephenson, D. Nadlinger, B. Nichol, S. An, P. Drmota, T. Ballance, K. Thirumalai, J. Goodwin, D. Lucas, and C. Ballance, High-Rate, High-Fidelity Entanglement of Qubits Across an Elementary Quantum Network, Physical Review Letters 124, 110501 (2020).

[3] P. Drmota, D. Main, D. Nadlinger, B. Nichol, M. Weber, E. Ainley, A. Agrawal, R. Srinivas, G. Araneda, C. Ballance, and D. Lucas, Robust Quantum Memory in a Trapped-Ion Quantum Network Node, Physical Review Letters 130, 090803 (2023).

Authors: MAIN, Dougal (University of Oxford); DRMOTA, Peter (University of Oxford); NADLINGER, David (University of Oxford); ARANEDA, Gabriel; AINLEY, Ellis (University of Oxford); Mr AGRAWAL, Ayush (University of Oxford); NICHOL, Bethan (University of Oxford); JUHASZ, Peter (University of Oxford); SRINIVAS, Raghavendra (University of Oxford); LUCAS, David (University of Oxford); MAIN, Dougal

Presenter: MAIN, Dougal (University of Oxford)

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