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A matter link for remote ion-trap modules

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The number of qubits in quantum computing architectures must be increased dramatically in order to demonstrate an advantage over classical hardware [1]. This "scaling up"must be performed without experiencing reductions in the rate, or the fidelity of the qubit operations. Multiple ions can be confined within a single ion trap. However, qubit gate times and the motional mode density scale with the size of the trapped ion crystal and effectively put an upper limit on the crystal size [2]. Remote links between several trapping regions or modules offer a solution to scaling beyond this limit. These links have so far been demonstrated with photonic interconnects, where photons mediate entanglement between ion crystals in separate traps [3]. A different approach to modularity has been proposed where the trapped ions themselves form a matter link between remote modules [4]. This matter link is established by the deterministic and coherent transfer of ions between spatially separated modules, and has previously remained an unexplored area of research. Here we report on the recent developments in demonstrating a shuttling-mediated matter link.

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[3] Stephenson, L. J., et al. "High-rate, high-fidelity entanglement of qubits across an elementary quantum network." Physical review letters 124.11 (2020): 110501.
[4] Lekitsch, B., et al. "Blueprint for a microwave trapped ion quantum computer." Science Advances 3.2 (2017): e1601540.

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