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Fast Entangling Gates with Trapped-Ion Qubits[1]

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Trapped ion qubits are one of the most promising candidates for scalable quantum computing. Entangling gates with trapped ions achieve higher fidelities than in any other system, but are typically performed in an adiabatic regime, where the motional frequencies of the ions in the trap limit the gate speed. Many schemes have been proposed to overcome these limitations, but have only now been successfully implemented[1,2]. Following [3] we use amplitude-shaped cw-pulses to perform entangling gates significantly faster than the speed limit for conventional gate mechanisms. At these gate speeds, the motional modes are not spectrally isolated, leading to entanglement with both motional modes sensitively depending on the optical phase of the control fields.

We perform gates with fidelity 99.8% in 1.6 μs[2] - over an order of magnitude faster than previous trapped ion gates of similar fidelity. We also demonstrate entanglement generation for gate times as short as 480 ns - this is below a single motional period of the ions.

[1] J.D. Wong-Campos et al., Phys. Rev. Lett. 117, 230501 (2017)

[2] V.M. Schäfer et al., arXiv:1709.06952 (2017), to be published in Nature

[3] A.M. Steane et al., New J. Phys. 16, 053049 (2014)

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