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Benchmarking high-fidelity mixed-species entangling gates

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The simultaneous trapping of two different species of ion allows the manipulation of one species without corruption of the electronic state of the other. Mixed-species systems therefore provide access to powerful tools such as sympathetic cooling and low cross-talk or quantum non-demolition measurement [1]. A high-fidelity entangling gate between two species offers the freedom to select ions with desirable properties for different tasks, and to transfer information from one to the other depending on the task at hand. Such a gate is an essential element in quantum logic spectroscopy [2], quantum networking [3] and quantum information processing.

In particular, $^{43}Ca^{+}$ and $^{88}Sr^{+}$ are well-suited for different aspects of quantum computing. Due to the transition frequencies in these two species, a two-qubit $\sigma_z \otimes \sigma_z$ gate [4] may be driven on both species simultaneously using a single pair of Raman beams, derived from a single frequency-doubled Ti:Sapphire laser. I present such a gate with fidelity 99.8(2)%, pushing mixed-species gate fidelities close to the best single-species entangling gates (99.9(1)% [5,6]). We use different methods to perform a full characterisation of this gate: with two-qubit randomised benchmarking we measure a fidelity of 99.72(6)% (99.60(5)%) with sequences involving up to 75 (125) entangling gates (or 30 (50) interleaved entangling gates). From gateset tomography we deduce a fidelity of 99.4(4)% for the two-qubit operations.

I further present progress towards a comparison of the $\sigma_z \otimes \sigma_z$ gate with a Mølmer-Sørensen gate [7] on the same mixed-species crystal.

References:

[1] D. B. Hume et al., Phys. Rev. A 99, 042302 (2007)
[2] P. O. Schmidt et al., Science 309 (5735), 749–752 (2005)
[3] R. Nigmatullin et al., New Journal of Physics 18 (10), 103028 (2016)
[4] D. Leibfried et al., Nature 422(6930), 412–415 (2003)
[5] C. J. Ballance et al., Phys. Rev. Lett. 117, 060504 (2016)
[6] J. P. Gaebler et al., Phys. Rev. Lett 117, 060505 (2016)
[7] A. Sørensen and K. Mølmer, Phys. Rev. Lett. 82, 1971–1974 (1999)

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