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# High fidelity two qubit gates with trapped ions

In order for quantum computation to become useful for practical purposes, it is necessary to be able to perform two-qubit entangling gates with fidelities high enough that quantum error correction can be applied. Therefore we have performed a careful analysis of the error sources of our system and by identifying the leading error sources we have decreased our two-qubit gate errors by nearly an order of magnitude and got closer to the fault tolerant regime. With a Bell state fidelity of 99.75(7)% we have observed the best two qubit gate fidelity reported so far. Our gate operations are driven by Raman lasers acting on two $^{43}Ca^{+}$ ions trapped in a linear Paul trap. To explore possibilities of coupling to photonic qubits and thus link several traps with each other, we have performed the same gate on two ions of different species ($^{43}$Ca & $^{40}$Ca) and achieved gate fidelities >99%. We have performed tomography on the created Bell state and have violated the CHSH-type Bell inequality by 23 standard deviations (S=2.23(1)).

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