Contribution submission to the conference Hamburg 2009

A long-distance quantum gate between matter qubits — •P. Maunz[1], S. Olmschenk[1], D. Hayes[1], D. N. Matsukevich[1], L.-M. Duan[2], and C. Monroe[1] — [1]Joint Quantum Institute and Department of Physics, University of Maryland, College Park, MD 20742 — [2]FOCUS Center and Department of Physics, University of Michigan, Ann Arbor, MI 48109

We demonstrate a probabilistic entangling quantum gate [1] between two distant trapped ytterbium ions. The gate is implemented between the hyperfine "clock" state atomic qubits and mediated by the interference of two emitted photons carrying frequency encoded qubits [2]. The successful operation of the gate is heralded by the coincidence detection of these photons.

On average, the gate has a fidelity of 90% and a success probability of 2.2×10^{-8}. For one pair of input states for which we expect the antisymmetric Bell state as output, we perform full tomography of the output state and obtain a fidelity of $F = 0.87$. We also apply this gate to teleport a quantum state between ytterbium ions separated by one meter [3].

This entangling gate together with single qubit operations is sufficient to generate large entangled cluster states for scalable quantum computing [4].

[1] L. Duan et al. Phys. Rev. A **73**, 062324 (2006).
[2] D. L. Moehring et al. Nature **449**, 68 (2007).
[3] S. Olmschenk et al. Science, to be published (2009).
[4] L. Duan and R. Raussendorf. Phys. Rev. Lett. **95**, 080503 (2005).