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Demonstration of two-qubit entanglement with ultrafast laser pulses.[1] DAVID WONG-CAMPOS, STEVEN MOSES, KALE JOHNSON, JONATHAN MIZRAHI, CHRISTOPHER MONROE, Joint Quantum Institute and University of Maryland Department of Physics, College Park, Maryland 20742 —
One of the major problems in building a quantum computer is the development of scalable and robust methods to entangle many qubits. In trapped ions, the use of electromagnetic fields for quantum control and entanglement generation has proven successful for small systems, but long interaction times relative to the trap oscillation period make the operation sensitive to a noisy background environment. In contrast, ultrafast pulses should enable interaction times much faster than external noise sources. Here we demonstrate a fully entangling phase gate between two trapped 171Yb+ ions using a sequence of spin-dependent ultrafast momentum kicks. Due to its fast nature, the demonstrated entangling gate is temperature independent and does not require ground state cooling. We verify entanglement by applying the entangling pulse sequence within a Ramsey interferometer and measuring the resulting parity oscillation. The best achieved fidelity is ˜60% in about 20 μs, which is limited by the spin-dependent kick fidelity. Future work includes systematically studying the limitations of the spin-dependent kick fidelity and speeding up the gate sequences to less than a harmonic trap evolution period.

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David Wong-Campos
Joint Quantum Institute and University of Maryland

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