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Ultrafast time scale X-rotation of cold atom storage qubit using Rubidium clock states[1] YUNHEUNG SONG, HAN-GYEOL LEE, HYOSUB KIM, HANLAE JO, JAEWOOK AHN, Department of Physics, KAIST — Ultrafast-time-scale optical interaction is a local operation on the electronic subspace of an atom, thus leaving its nuclear state intact. However, because atomic clock states are maximally entangled states of the electronic and nuclear degrees of freedom, their entire Hilbert space should be accessible only with local operations and classical communications (LOCC) [1]. Therefore, it may be possible to achieve hyperfine qubit gates only with electronic transitions. Here we show an experimental implementation of ultrafast X-rotation of atomic hyperfine qubits, in which an optical Rabi oscillation induces a geometric phase [2] between the constituent fine-structure states, thus bringing about the X-rotation between the two ground hyperfine levels. In experiments, cold atoms in a magneto-optical trap were controlled with a femtosecond laser pulse from a Ti:sapphire laser amplifier [3]. Absorption imaging of the as-controlled atoms initially in the ground hyperfine state manifested polarization dependence, strongly agreeing with the theory. The result indicates that single laser pulse implementations of THz clock speed qubit controls are feasible for atomic storage qubits. [1] Quantum Inf. Comput. 7, 1 (2006). [2] Phys. Rev. B 74, 205415 (2006). [3] Phys. Rev. A 91, 053421 (2015).

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