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Ultrafast Spin-Motion Entanglement and Interferometry with a Single Atom JONATHAN MIZRAHI, BRIAN NEYENHUIS, KALE JOHNSON, CHRIS MONROE, University of Maryland, Joint Quantum Institute — We report entanglement of a single atom's hyperfine spin state with its motional state in a timescale of less than 3 ns. We engineer a short train of intense laser pulses to impart a spin-dependent momentum transfer of $2\hbar k$. We further create an atomic interferometer using pairs of momentum kicks and demonstrate collapse and revival of spin coherence as the motional wavepacket is split and recombined. The revival after a pair of kicks occurs only when the second kick is delayed by an integer multiple of the period of the harmonic trap, a signature of entanglement and disentanglement of the spin with the motion. Such quantum control may allow a new regime of ultrafast entanglement between atomic qubits.

Jonathan Mizrahi
University of Maryland, Joint Quantum Institute

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