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Quadrature interferometry for nonequilbrium ultracold atoms in optical lattices[1] PHILIP JOHNSON, American University, EITE TIESINGA, Joint Quantum Institute, NIST and University of Maryland — We propose an interaction-based interferometric technique for making time-resolved measurements of quadrature operators of nonequilibrium ultracold atoms in optical lattices. The technique creates two subsystems of magnetic atoms in different spin states and lattice sites–the arms of the interferometer. A Feshbach resonance turns off atom-atom interactions in one spin subsystem, making it a well-characterized reference state, while atoms in the other subsystem undergo nonequilibrium many-body dynamics for a variable hold time. The nonequilibrium evolution can involve a variety of Hamiltonians, including systems with tunneling and spin-orbit couplings using artificial gauge fields. Interfering the subsystems via a second beam-splitting operation, time-resolved quadrature measurements are directly obtained by detecting relative spin populations. Analyzing a simple application of the interferometer, we obtain analytic predictions for quadratures for deep optical lattices with negligible tunneling. As a second, distinct application, we show that atom-atom interaction strengths can in principle be determined with super-Heisenberg scaling $n^{-3/2}$ in the mean number of atoms per lattice site n, making it possible to test the physics of interaction-based quantum metrology.

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