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Quantum Walks and Bloch Oscillations of Strongly Interacting Bosons PHILIPP PREISS, RUICHAO MA, M. ERIC TAI, ALEX LUKIN, MATTHEW RISPOLI, K. RAJIBUL ISLAM, MARKUS GREINER, Harvard University — Microscopy techniques for ultracold quantum gases offer the opportunity to characterize complex bosonic many-body states on a single-particle level. With a novel single-site addressing scheme, we are now able to study the most elemental building blocks of such strongly correlated systems. We initialize Fock states of few bosons in an optical lattice with high fidelity and follow their dynamics in one dimension. Focusing on free quantum walks of two atoms, we directly observe the crossover from bunching to anti-bunching as the bosons fermionize due to strong repulsive interactions. We utilize our control over the initial state to prepare repulsively bound pairs and study their coherent Bloch oscillations in the presence of an externally applied gradient. Our work gives access to interaction effects in the simplest possible setting and allows the assembly of many-body states one particle at a time.

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