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In-Situ Imaging of an Atomic Gas in a Two-Dimensional Optical Lattice NATHAN GEMELKE, CHEN-LUNG HUNG, XIBO ZHANG, CHENG CHIN, Department of Physics and James Franck Institute, University of Chicago — We describe studies of quantum many-body phases and few-body physics using interacting ultracold ^{133}Cs atoms confined in optical lattices. The realization of the superfluid to Mott- insulator phase transition with neutral atoms in an optical lattice provides a tantalizing opportunity to test many-body physics with a high degree of accuracy. We report progress toward a quantitative comparison of the superfluid to Mott- insulator phase boundary with results from the Bose- Hubbard model, using in-situ imaging of Bose-condensed cesium atoms confined to a thin layer of a two-dimensional optical lattice potential. Scrutiny of this phase boundary forms a first step toward generalized quantum simulation, and promises future application to the study of quantum critical phenomena. To induce the phase transition, we employ Feshbach resonances to scan the on-site interaction energies over a wide range without modifying the tunneling rate and the overall trapping potential. High-resolution in-situ imaging of the two- dimensional density profile permits detailed studied of the compressibility of the Mott-insulating and superfluid phases, without complications from line-of-sight integration. We will discuss the extension of these results to the strongly interacting regime, and the application of insulator physics to few-body collision studies.

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