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In situ Microscopy of an Ultracold Atomic Gas near a Quantum Phase Transition XIBO ZHANG, CHEN-LUNG HUNG, NATHAN GEMELKE, CHENG CHIN, University of Chicago — In situ observation of quantum phases in ultracold atoms realizes a key step in experimental many-body physics. By identifying coexisting local phases in an inhomogeneous system, in situ imaging holds promise for studying quantum criticality and dynamics. Here we study the bosonic superfluid (SF) to Mott insulator (MI) transition by applying high resolution imaging to a large 2D sample to identify the emergence of new phase domains near the critical point. Starting from a cesium 133 BEC loaded into a 2D potential, we drive the SF to MI transition by ramping up a 2D optical lattice. The surface density is measured by absorption imaging along the tightly confined direction. To identify the phases, we compute the local compressibility from the averaged density profile. As the final lattice depth is increased, the cloud center develops a flattened density plateau with almost zero compressibility, indicating a MI phase. We also observe suppressed density fluctuation in the MI domain, which is consistent with the fluctuation-dissipation theorem. Our technique can be extended to explore quantum fluctuations, correlations, thermodynamics, and dynamics in the quantum critical regime.

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