Electron Microscopy of Ultracold Quantum Gases

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Scanning electron microscopy is routinely used to study solid objects on a nanometer scale. Applied to ultracold quantum gases it constitutes a powerful imaging and manipulation technique that combines single atom sensitivity with high spatial resolution.
We have adapted a scanning electron microscope for the study of Bose-Einstein condensates of rubidium atoms. The focussed electron beam ionizes the atoms which are subsequently detected. The technique allows for high precision density measurements of the trapped gas with a spatial resolution of better than 150 nm. Loading the condensate in a two-dimensional optical lattice with 600 nm period we demonstrate single site addressability and show that one can produce arbitrary patterns of occupied lattice sites. Such micro-structured quantum gases might become a versatile resource for the study of mesoscopic quantum systems and future applications in quantum simulation and quantum information processing.
Ultimately, we want to employ this technique to make snapshots of the many-body wave function and to get *in situ* access to the quantum correlations of bulk, lattice and low-dimensional quantum systems.