Frontiers in Optical Coherent and Ultrafast Science
A National Science Foundation Physics Frontier Center at
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A nugget from FOCUS:

Title: 1-D Mott insulator transition of a Bose-Einstein condensate

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Recently, the 1-D Mott insulator was observed for the first time. This demonstration of a previously unattainable crystalline state using easily controllable atomic systems helps bridge the gap between solid-state and atomic physics. It could also have applications in quantum computing.

To create a Mott insulator, it is necessary to start with a Bose-Einstein condensate (BEC): a group of atoms so cold and dense that they all occupy the same quantum-mechanical state. The BEC, which is macroscopic, acts as a single matter wave, exhibiting quantum-mechanical behavior—behavior normally only observed in microscopic, difficult-to-see objects.

When an optical lattice—a set of standing waves created by pairs of counter-propagating laser beams, simulating a crystal lattice—is applied to a BEC, and the lattice depth is slowly increased, the BEC undergoes a transition to a new quantum state: it becomes a Mott insulator. In this work, the transition was demonstrated using a one-dimensional optical lattice (a single pair of beams). The resultant 1-D Mott insulator consists of a 2-D pancake-shaped BEC in each well of the lattice. If the lattice is abruptly turned off, the BEC pancakes expand into each other. Since each pancake is a separate matter wave, when the pancakes overlap they create interference patterns, similar to light shined through several slits, or water waves hitting an array of poles.

As with any transition between states of matter, the 1-D Mott insulator transition is fully reversible; when the lattice depth is slowly decreased the system reverts back to a BEC.

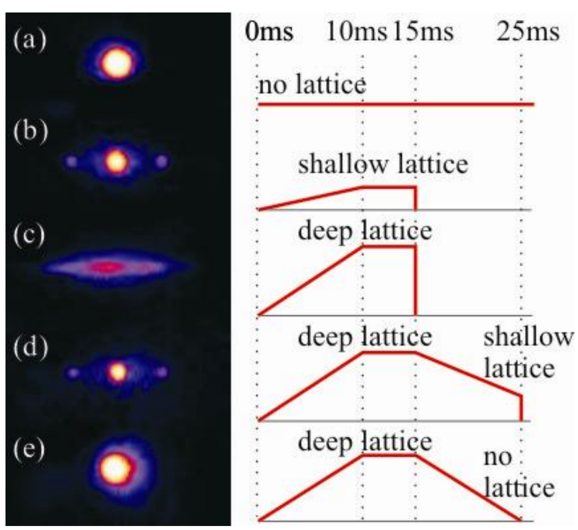

Figure: (a) BEC, **(b)** BEC in a shallow lattice, **(c)** Mott insulator in a deep lattice, **(d)** BEC in a shallow lattice after Mott-insulator transition, **(e)** BEC with no lattice after Mott-insulator transition.