Mott Insulators in Ultracold Atomic Gases

Recent experiments with ultracold atomic gases have created the Mott state, an insulating condition that might offer many clues to understanding superconductivity and the fundamental factors that enable electrical conductivity in metals. Some materials that ought to be conductors instead are insulators, specifically Mott insulators, which result from strong interactions between electrons. Ultracold atomic systems offer the ability to study the Mott state in a pristine and carefully controlled system, compared to condensed-matter materials, which are messy and much harder to control. New results in studying the Mott state in atomic gases will be reported in papers such as R43.6 (Ana Maria Rey, Harvard-Smithsonian, arey@cfa.harvard.edu) and U43.5 (Ian Spielman, ian.spielman@nist.gov).

Casimir-Like Force May Drag Some "Super" out of Superfluids

One of the most dramatic features of superfluids is that at very low temperatures (close to absolute zero) they seem to flow without friction below a certain well-defined speed. This was the "super" attributed to superfluids upon their discovery in liquid helium by Russian scientist PL Kapitza in 1938. In other words, an object in a (slow) moving superfluid flow should not appear to feel a drag force, unlike in moving "normal" fluids where the object is pushed in the flow direction. But upon closer inspection, argue David Roberts (d.roberts1@physics.ox.ac.uk) and Yves Pomeau of the Ecole Normale Superieure, even at slow flow speeds an object in a superfluid will experience a small force. The researchers draw an analogy to the work of physicist Hendrik Casimir who famously predicted in 1948 that, if two uncharged parallel conducting plates are brought close together in a perfect vacuum, an attractive force would arise between them . This "force from nothing" was measured to a high degree of accuracy by Steve Lamoureaux at Los Alamos in 1997. Similarly, the researchers show that a repulsive force should arise between two walls immersed in a superfluid Bose-Einstein condensate in which the atoms are weakly interacting, with the "vacuum" corresponding to the absence of collective excitations among the atoms. Extending this idea, the researchers show that an object in a slow-moving infinitely extended superfluid should feel a slight damping force. The researchers think that this effect could be observed in current experiments involving BECs in trapped ultracold atoms, particularly in the "persistent current" setups presently being built in a few labs. While the infinite superfluid arrangement is qualitatively different from real-world realizations of superfluids, akin to calculating the drag force on a boat in an endless sea when real-world experiment involve boats flowing through narrow channels, this theoretical work may provide some fundamental new insights into superfluidity in conjunction with upcoming experiments. (B43.4)