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Abstract for an Invited Paper
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Davisson-Germer Prize Talk: Many-Body Physics with Atomic Fermions[1]

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Ultracold atomic gases confined to optical lattices have proven to be highly versatile and tunable systems for realizing novel quantum states of matter. We are using Fermi gases of ^{6}Li atoms in our laboratory to explore several goals related to the strong correlations that arise in these systems. We have realized the Hubbard model, which has long been suspected of containing the essential ingredients of high temperature superconductivity. We measured the compressibility of the Mott insulating phase that occurs near half filling (1 atom/site), thus demonstrating the excitation gap of the Mott insulator. Progress in this field, however, has been hampered by an inability to cool to low enough temperatures to achieve the most ambitious goals. To address this problem, we have developed the compensated optical lattice method to enable evaporative cooling in the lattice. With this method, we have cooled the Mott insulator sufficiently far to observe short-range antiferromagnetic correlations using Bragg scattering of light. We are currently exploring new methods for entropy storage and redistribution to achieve even lower entropy in the antiferromagnetic phase. Motivated by the enhancement of quantum correlations in low dimensions, we are also exploring Fermi gases in quasi-one-dimension (1D). A deep 2D optical lattice produces an array of 1D tubes which can be weakly coupled by reducing the lattice depth, thus increasing the lattice hopping t between them. We observe a crossover from 1D-like to 3D-like behavior in the phase separation of a spin-imbalanced Fermi gas with increasing t. While this crossover occurs at a value of t that depends on interaction, we find that the crossover location is universally dependent upon the scaled hopping $t/\varepsilon_{\mathrm{b}}$, where ε_{b} is the pair binding energy. Finally, I will also report progress on measuring the speed of sound of the charge and spin modes in a 1D Fermi gas.

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