MAR15-2014-020347

Abstract for an Invited Paper
for the MAR15 Meeting of
the American Physical Society

Observation of Antiferromagnetic Correlations in the Hubbard Model with Ultracold Atoms[1]

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Ultracold atoms on optical lattices form a versatile platform for studying many-body physics, with the potential of addressing some of the most important issues in strongly correlated matter. Progress, however, has been stymied by an inability to create sufficiently low temperatures in an optical lattice. In this talk, I will present our experimental results on the characterization of the three-dimensional Hubbard model near half-filling, realized using two spin-states of fermionic atomic lithium (^{6}Li). We have developed a compensated optical lattice that has enabled, for the first time, the achievement of temperatures that are below the tunneling energy, t. We use *in-situ* imaging to extract the central density of the gas, and to determine its local compressibility. For intermediate to strong interactions, we observe the emergence of a density plateau and a reduction of the compressibility, indicative of the formation of a Mott insulator. Comparisons to state-of-the-art numerical simulations of the Hubbard model over a wide range of interactions set an upper limit for the temperature $T < t$.[3] The Hubbard model is known to exhibit antiferromagnetism at temperatures below the Néel temperature T_N. We have detected antiferromagnetic correlations in this system by spin-sensitive Bragg scattering of light. We deduce the temperature of the atoms in the lattice by comparing the light scattering to determinantal quantum Monte Carlo and numerical linked-cluster expansion calculations to find that $T/t = 0.51 \pm 0.06$, corresponding to $1.4\, T_N$.[4] Further refinement of the compensated lattice may produce even lower temperatures which, along with light scattering thermometry, have important implications for achieving other novel quantum states of matter.

[1]Supported by DARPA/ARO, ONR, NSF.

[2]Work done in collaboration with P.M. Duarte, R.A. Hart, T.L. Yang, X.X. Liu, T. Paiva, E. Khatami, R.T. Scalettar, N. Trivedi, and D.A. Huse.

[3]P.M. Duarte *et al.*, arXiv:1409.8348

[4]R.A. Hart *et al.*, arXiv:1407.5932