Abstract Submitted
for the DAMOP11 Meeting of
The American Physical Society

Signatures of quantum criticality in cold atoms and resolution of the Fermi-Hubbard model's high temperature Mott/metal crossover

KADEN HAZZARD, ANA MARIA REY, JILA, NIST, and Dept. of Physics, CU-Boulder, RICHARD SCALETTAR, Physics Department, UC-Davis — We present general techniques to observe and characterize quantum critical behavior in cold atoms. Quantum criticality — behavior manifested at finite temperature near a zero temperature phase transition — is a central concept in condensed matter physics. It provides a key example of excitations incapable of being described by the quasi-particles and is crucial to interpreting experiments on real materials. We give a prescription to use cold atoms to resolve major open questions of the field. As one example, it is important to know the spectrum of the so-called "finite density O(2) rotor model," which could be measured by spectroscopy of bosons in optical lattices or dynamics of spinor condensates. Moreover, applying these techniques to data from numerical determinental quantum Monte Carlo calculations, we have been able to resolve the universality class of the Mott/metal crossover in the Fermi-Hubbard model at temperatures $t^2/U \ll T \ll t$, with t the tunneling rate and U the interaction strength. We find that the universal physics is quantitatively described by a $z = 2$ dilute Fermi gas universality class, in contrast to several other proposed scenarios. This also provides a new perspective on current fermion lattice systems' observed density profiles, doublon fractions, and compressibilities.

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Date submitted: 04 Feb 2011 Electronic form version 1.4