Abstract Submitted
for the DAMOP09 Meeting of
The American Physical Society

Interacting Bosonic and Fermionic Atoms in 3D Optical Lattice Potentials SEBASTIAN WILL, THORSTEN BEST, SIMON BRAUN, ULRICH SCHNEIDER, LUCIA HACKERMÜLLER, IMMANUEL BLOCH, Johannes Gutenberg-University Mainz — Mixtures of ultracold gases form novel quantum many-body systems offering unique experimental controllability. Depending on interaction strength, number of particles and temperature, these systems can display rich phase diagrams with close analogies to condensed matter physics. Particularly in the presence of a periodic potential, such mixtures are expected to show the formation of anti-ferromagnetic ordering, charge-density waves, polaron-like quasiparticles or even supersolid-ordering. In our 3D optical lattice setup we investigate both Fermi-Fermi mixtures formed by two distinct spin states of ^{40}K as well as Bose-Fermi mixtures consisting of ^{87}Rb and ^{40}K atoms. In the case of Fermi-Fermi mixtures we have directly measured the compressibility of the quantum many-body system. This allowed us to identify metallic, Fermi liquid and insulating phases. For strong interactions, evidence for an emergent incompressible Mott-insulating phase was found. On the side of Bose-Fermi mixtures we could elucidate effects of interspecies interactions by analysing long-range phase coherence properties and performing absolute measurements of interaction energies using quantum phase diffusion. The current status of our projects will be presented.

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Date submitted: 22 Jan 2009 Electronic form version 1.4