DAMOP10-2010-020123

Abstract for an Invited Paper
for the DAMOP10 Meeting of
the American Physical Society

Overcoming the grand challenges in Quantum Simulations

QI ZHOU, Joint Quantum Institute and Condensed Matter Theory Center, University of Maryland

The highly ambitious goal of the "Quantum Simulation" program is to simulate the behavior of strongly correlated solid-state systems using cold atoms in optical lattices. It promises to provide insight into a range of long-standing problems in many-body physics. There are, however, significant challenges which need to be overcome in order for these efforts to succeed. The first challenge is that the required temperatures for studying strongly correlated physics in optical lattices are far below those achievable in laboratories today. The second problem concerns the fact that many important thermodynamic qualities, which distribute non-uniformly in the confining trap, are inaccessible by standard imaging methods. In this talk, I will discuss ways to solve these grand challenges. First, I will present schemes which allow for strongly correlated regimes of atoms in optical lattices to be reached. These schemes are based on transferring the entropy out of the region of interest. Examples will be given to demonstrate that these schemes can reach temperature regions down to a few tens of pico-Kelvin. Secondly, I will discuss algorithms to map out the phase diagrams of quantum models and deduce the thermodynamic properties of homogeneous systems, such as the superfluid density and entropy density, which have eluded cold atom experiments for years. Using only the density profile of trapped atoms as input, these algorithms can fulfill the lofty goal of quantum simulation.