Transport in three dimensional optical lattices

Simone Kulin and Steven Rolston

National Institute of Standards and Technology, Gaithersburg, MD 20899-001

Abstract

Optical lattices have been studied by a number of groups over the past few years. While cooling mechanisms in these systems are well understood, less is known concerning transport phenomena. At NIST our aim is to study quantum transport in three dimensions. By working in a lattice of metastable xenon atoms, we have many useful diagnostics available, including the ability to monitor direct atom-atom interactions via Penning ionizing collisions, count atoms individually as they leave the lattice, and make direct imaging measurements of the spatial diffusion. The experiments done to date raise two as yet unanswered questions that are relevant for transport phenomena: 1. Why do atoms leak out of our lattice at all? Can it be tunneling? 2. Earlier work on collision suppression allowed us to infer the rate at which atoms "hop" from one lattice site to another. To our surprise, this "hopping rate" is not proportional to the optical pumping rate. What other mechanisms, then, are responsible for "hopping"? We discuss the experiments under way to directly measure the spatial diffusion of the atoms in the optical lattice. We hope that these measurements will allow us to distinguish between the regime in which atomic motion is determined by tunneling and the case in which it is purely diffusive.