Stony Brook University
The Graduate School

Doctoral Defense Announcement

Abstract

Dynamics of Matter Waves in Optical Lattices

By

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Quantum gases in optical lattices allow for fundamental studies in atomic and condensed-matter physics and the exploration of novel effects. Here we give a brief introduction to the fundamentals of quantum gas experiments in optical lattices and discuss two recent experiments focusing on driven matter waves in a one-dimensional optical lattice.

The first experiment uses a tilted bichromatic optical lattice to investigate the interplay of disorder and collisional interactions in the accelerated transport of a Bose-Einstein condensate. We find that a screening effect is observed, in which the interactions effectively cancel the damping of Bloch oscillations induced by a (quasi)disordered potential. This effect can be understood through a modification of the underlying band structure by the interactions.

The second experiment studies the dynamics of a weakly trapped condensate resonantly coupled to the orbitals of a strongly confining state-selective lattice. We observe momentum distributions that correspond to matter-wave diffraction from a periodic structure; however, the diffractive dynamics remain strongly linked to the internal-state Rabi oscillations. In the regime investigated, which we call the nonadiabatic regime, no diffracting potential can be defined. We show how only for much stronger coupling, the internal and external dynamics decouple, transitioning from nonadiabatic diffraction to the well-studied Kapitza-Dirac diffraction.

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