Semiclassical Description of Intrinsic Photoconductivity of Ultracold Fermions in Optical Lattices

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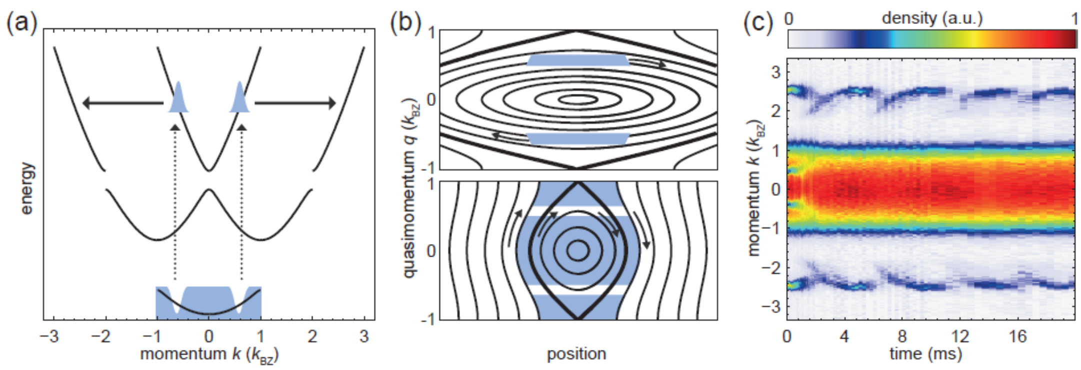
We present theoretical analysis of recent Hamburg experiments reported in [1,2]. Ultracold fermionic atoms in optical lattices were used to simulate the phenomenon of photoconductivity. Using amplitude modulations of the optical lattice, the analog of a persistent alternating photocurrent was induced in the atomic gas (Fig. 1). A small fraction of the atoms was excited to the third band as a wavepacket with a well-defined quasimomentum, leaving a hole in the momentum distribution of atoms in the lowest band. The subsequent dynamics is due to an external harmonic trap. It was observed that the particle excitations in the third band exhibit long-lived oscillations with a frequency determined by the initial quasimomentum, while holes in the lowest band behave strikingly differently: an initial fast collapse was followed by periodic partial revivals. We explain both observations by a semiclassical approach to lattice dynamics. By using the Truncated Wigner Approximation and mapping the system onto a classical Hamiltonian resembling a nonlinear pendulum, both the long-lived particle oscillations and decaying hole revivals are understood quantitatively. Numerical solutions of the many-particle system of trapped spinless fermions confirm accuracy of the semiclassical approach [3].

Fig.1 Scheme of excitation of fermionic cloud (a), semiclassical phase space of dynamics in the lowest and excited bands (b), time evolution of momentum distribution of fermions (c)



References:

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