Mesoscopic Transport of Ultracold Atoms in Optical Lattices

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Ultracold atoms in optical lattices have been shown to be perfectly suitable for implementing physical models of fundamental interest to the field of atomic and condensed matter physics.[1] In particular, ultracold systems have the advantage that they exhibit slow coherent dynamics (with kilohertz tunneling rates) and, more importantly, that single atoms are detectable on microscopic scales. We show how these features can be exploited to study mesoscopic transport of ultracold atoms in a specific setup, namely two atomic reservoirs connected by a short optical lattice.[2]
For our analysis in the tight-binding regime we use the non-equilibrium Green's functions formalism extended to include the time dependence of the reservoirs. This allows us not only to determine the mean atomic current between the reservoirs but also the full counting statistics (FCS) of the atomic transport, i.e., shot noise and higher order cumulants. We argue that these quantities can be readily determined in experiments by counting the atoms in the reservoirs. Furthermore, we show that time-dependent modulations of the short optical lattice result in mesoscopic phenomena such as coherent suppression of tunneling and non-adiabatic quantum pumping.

[1] I. Bloch, J. Dalibard, and W. Zwerger, Rev. Mod. Phys. **80**, 885 (2008).
[2] R. A. Pepino, J. Cooper, D. Z. Anderson, and M. J. Holland, Phys. Rev. Lett. **103**, 140405 (2009).