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Quantum transport between finite reservoirs

Abstract: The transport of particles across a system connecting two reservoirs is not only determined by the system's Hamiltonian and by the coupling to the leads, but also by the time evolution of the reservoirs - which cannot be considered stationary if composed of a finite number of particles. While the initial particle number imbalance between the reservoirs drives a non-stationary current across the system, the latter will reduce that imbalance until equilibration is reached. Via an open quantum system treatment, we devise a set of nonlinear coupled quantum-classical master equations which fully describe the time evolution of the populations of system and reservoir degrees of freedom, respectively. Our approach, valid both for fermionic and bosonic particles, furthermore highlights how – in the absence of particle interactions – quantitative discrepancies between fermionic and bosonic transport only manifest on the level of two rather than single particle observables. Underpinned by ample numerical simulations, we analyse the various time scales which emerge in the short- and long-time evolution, as a consequence of the interplay between different coupling agents.