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QUANTUM DIFFUSION: A SIMPLE, EXACTLY SOLVABLE MODEL

Wim MAGNUS and Kwinten NELISSEN
Universiteit Antwerpen, Department of Physics, Condensed Matter Theory
Antwerpen, Belgium

Abstract:

We have used a simple, quantum mechanical model to compute the time dependent diffusion current flowing between two fermion reservoirs that were initially disconnected. Characterizing the initial equilibrium state of the two fermion systems by two different chemical potentials, we obtain the exact, analytical solution of the model tracing the transient evolution of the coupled fermion system towards its final steady state.

As a result, a power law rather than an exponential decay law governs the long-time behavior of the fermion density and the corresponding diffusion current. Exhibiting substantial transient overshoot, the time dependent densities are found to decay according to 1/t in the quantum limit (high initial density and/or low temperature), whereas the classical limit reveals a smooth 1/t^2 decay. A similar conclusion follows for the entropy production, which is directly proportional to the diffusion current.