Hydrodynamics from quantum-corrected BGK kinetic equations

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In modern integrated electron devices, the layer thickness approaches the typical De Broglie length of the electron in the crystal and the quantum-mechanical nature of the particles emerges. The description of the particle motion by a full quantum approach where particle-particle interaction of phonon scattering processes are included leads to very complex models, whose application to real device is usually prohibitive.

In [1], by using a non-linear minimization procedure, some quantum corrections to the particle transport in a semiconductor are derived. In this approach the classical language is preserved and the particle motion is described in term of a well-defined non-linear quantum trajectory. The corrections to the Newton motion are obtained within the Liouville formalism and are expressed by an effective nonlinear force. This effective force describes the non-local character of the quantum particles. This offers the considerable advantage that some quantum corrections can be easily included in terms of a non-linear force and integrated, for example, in a classical code.

In this work, we derive new solvable quantum-corrected hydrodynamic and drift-diffusion models for the out-of-equilibrium particle dynamics in the presence of particle collisions, modeled by a BGK collision term.