Quantum hydrodynamic models for multiband semiconductor devices.

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In the modeling of modern semiconductor devices it is essential to incorporate quantum mechanical phenomena, as in the new families of tunneling devices. From the point of view of practical applications, the approaches based on microscopic models are not completely satisfactory. Hence, it is useful to formulate semi-classical models in terms of macroscopic variable. Such models are generally built by a hierarchy of coupled moment equations and referred to as quantum hydrodynamic models [1].

A new family of tunneling devices is the family of the heterojunction resonant interband tunneling diodes, which makes use of resonant interband tunneling through potential barriers. For these devices, we have to consider the multi-band structure in the transport computation of the current. A simple model introduced by E.O.Kane [2] in the early 60's describes the electron behaviour in a system equipped with two allowed energy bands separated by a forbidden region.

The Kane model, as the simplest framework for including one conduction band and one valence band (light hole) in each material of the heterogeneous device, was reformulated in terms of Wigner functions in [3].

In this paper, starting from the Wigner equations for the two band Kane model, we derive formally a system for the zeroth, first and second velocity moments. A simpler quantum hydrodynamic model is obtained directly from the two equations of the Schrödinger-like Kane system, introducing phases of the envelope functions and current densities for each band.

Here we present only the first preliminary results and the future perspectives are addressed towards the mixed state Wigner functions and the closure of the moment equations. Also numerical validation of the models for realistic tunnel diodes are in progress.

References

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