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Quantum corrections to electron hydrodynamics in graphene

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In recent times the hydrodynamic behaviour of electrons in graphene has attracted much interest from both the theoretical and experimental viewpoints (see Refs. [1, 2] and references therein). The usual approach to the mathematical modeling of such behaviour is "semiclassical", to the extent that the hydrodynamic equations are derived from an underlying kinetic description based on the semiclassical Boltzmann equation [2].

Then, it would be interesting to find subleading quantum corrections to the semiclassical description, which means including terms of order $\hbar$ or higher. The procedure to compute such corrections is well known for electrons in ordinary semiconductors and is based on the Wigner equation and on the quantum maximum entropy principle (QMEP) [3]. However, such procedure proves to be difficult in graphene, due to the conical shape of the energy bands. In [4], quantum corrections for graphene hydrodynamics are obtained with the QMEP in the assumption that the energy bands have a regularised form, depending on a (small) energy-gap parameter α. The resulting hydrodynamic model becomes singular when $\alpha \to 0$.

In the present work we address the problem of the singularity and discuss a strategy to overcome this.

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