Ballistic motion in periodic Lorentz gas model with magnetic field.

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Quantum antidots systems have been manufactured with high perfection in the last years. This open the possibility to control the geometry of the array where electrons will move. The change of the geometry translate in a change of the electronic properties. In addition, when we apply a magnetic field, the electrons have circular motion, and thus, the resistance change (there is magnetorresistance). At low temperatures, electrons can be considered as non-interacting. Also, if the lattice constant of the quantum antidots array is larger than the Fermi wave length of the electrons, of the order of 50nm, it is expected that the transport properties can be approximated by a classical model. Then, the system can be well approximated by a Lorentz gas-like model, where particles follow a circular trajectory. Periodic and quasiperiodic Lorentz gas models usually exhibit normal diffusion or weak super-diffusion with logarithmic correction in the mean square displacement (MSD) due to channels where particles can move with straight trajectories without collide with any obstacle. Adding a magnetic field to this model would destroy these straight trajectories. However, as it has been shown, (and we will show it as well in this work), there are stable trajectories that effectively move only in one direction with constant velocity. Then, adding a magnetic field can make the system super-diffusive, with ballistic motion. On the other hand if the stability of the ballistic-like trajectories is broken, the system should exhibit normal diffusion i.e., MSD goes like t, but we also know that when the magnetic field is zero, the system has weak super-diffusion, i.e., MSD goes like $tlog(t)$. Finally, if the magnetic field is strong enough, the particles will be localized, which means there is no diffusion. We are interested on which kind of diffusion (conductance) exhibit the system for intermediate magnetic field.
In the case where there is a positive probability to fall in a ballistic-like trajectory, the diffusive properties of the system will be dominated by those trajectories. Therefore, the velocity of those trajectories will determinate the diffusive properties. In this work we discuss, numerically and theoretically, the stability of the ballistic-like trajectories, the velocity distribution of these trajectories, and the critical values of the magnetic field.

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