# Quantum electron transport in low dimensional devices

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**Abstract**: Many electronic devices are based on one or two-dimensional structures in which electron transport is quantum. Often, the interactions between electrons themselves and scattering with phonons, lattice imperfections, etc. produce nonlinear phenomena at the mesoscopic level. Examples include high-frequency oscillations that can be used to build sensors, oscillators, and other devices. In these lectures, we will explain how to build quantum kinetic equations by adding collective electron effects to the dispersion relations obtained by solving models of independent electrons. These kinetic equations are then approximated at appropriate limits to yield balance equations for electron and current densities, temperature, and so on. Studying the attractors of the latter equations allows us to understand, propose and design different devices. The mathematical tools we use come from perturbation theory and deterministic and stochastic dynamical systems.

Outline:

- Quantum electron transport in a semiconductor superlattice device: basic electronic states for independent electrons and kinetic Wigner-Poisson equations for transport. From Wigner-Poisson equations to balance equations for macroscopic quantities in the semiclassical limit. Nonlinear oscillations and chaos under an applied magnetic field.

- Resonant tunneling transport in semiconductor superlattices 1: derivation of model equations, nonlinear stationary states and self-sustained oscillations of the current through the device. Using external noise to induce coherence resonance and stochastic resonance and detect weak signals.

- Resonant tunneling transport in semiconductor superlattices 2: chaotic attractors at room temperature and application to build an ultrafast device generating true random numbers of interest in secure communications and data storage.

- Brief descriptions of quantum transport in graphene and other two-dimensional materials.