II I-Math School on Numerical Solutions of PDE
Málaga, February 8–12, 2010

Numerical solvers for kinetic equations in semiconductors theory and neuroscience.

María José Cáceres.[1]

The aim of this talk is to show some deterministic numerical solvers for different kinetic equations: the Boltzmann equation for semiconductors and Fokker-Planck equations in Neuroscience. These schemes are based on fifth order WENO-finite differences for the advection part, a "upwind" scheme mixed with a "θ-scheme" (Chang-Cooper method) for the diffusion term (in the Fokker-Planck equation) and the evolution on time is done by means of a TVD third-order Runge-Kutta method. All of these schemes were compared with Direct Simulation Monte Carlo.

Statistical models are used to describe electron transport in semiconductors at a mesoscopic level. The basic model is given by the Boltzmann transport equation for semiconductors in the semi-classical approximation coupled with Poisson's equation, since the electric field is self-consistent due to the electrostatics produced by the electrons and the dopants in the semiconductor. When the size of the devices is reduced, quantum effects have to be considered and, in this case, the Boltzmann-Schrödinger-Poisson system models the behavior of the electron transport.

In this talk we show WENO-solvers for these systems for different devices. The main differences of the devices are in the material (Si or GaAs) and the geometries (MESFET, MOSFET or nanoMOSFET).

Concerning Neuroscience, we are interested in a Fokker-Planck model, which describes the behavior of neuronal networks in the mammalian neocortex. In the mammalian brains there are around 10^{10} neurons, which represents a sufficiently large number to think of a kinetic approach as appropriate. This Fokker-Plank equation was derived directly from conductance-based integrate-and-fire neuronal networks. We analyze a numerical solver for this model, which allows us to obtain the numerical evolution of the solution and to consider the distribution function depending of all the variables.

This is talk is a series of works in collaboration with N. Ben Abdallah, J. A. Carrillo, I. Gamba, A. Majorana, J. M. Mantas, P. Degond, C.-W. Shu, L. Tao and F. Vecil.

[1]Departamento de Matemática Aplicada
Universidad de Granada, Spain