Minisymposium *Charge and Spin Transport in Nanostructures*

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Electronic transport is the basis of many nanotechnology applications. Spin transport and spintronics are used to create better computer memories, whereas basic science and many interesting device applications are being actively pursued. In nanoelectronic devices, the interplay between charge, spin and vibrational degrees of freedom determines their main electronic and transport features. Moreover, the dimensionality and the number of atoms determines the more suitable theoretical framework and numerical techniques for each particular system. In this minisymposium, different models of quantum charge and spin transport in low-dimensional nanostructures were discussed.

Prof. V. Romano (U. of Catania, Italy) considers the problem of describing electrons in a single band subject to an external electrostatic potential and in equilibrium with a phonon bath. He analyzes the semiclassical limit in which the electron wavelength is small compared to the scale of the potential ($\hbar \to 0$). The method consists of writing an equation for the equilibrium density matrix, transforming this equation via the Wigner transform in an equation for the Wigner function, and expanding nonlocal terms thereof in powers of $\hbar$. The solution of the resulting equation is then approximately solved by regular perturbation methods. Results are given for a band with a nonparabolic Kane dispersion relation.

Dr. L. Barletti (U. of Florence, Italy) and collaborators discuss superlattices (SL) with Rashba spin-orbit effects. These structures are artificial one-dimensional crystals (with finitely many periods). In materials with spin-orbit effects, electrons with different spin have different energies and can transport spin. The paper presents a simple quantum kinetic equation for the SL. Using singular perturbations, Barletti et al. derive spatially nonlocal equations for the electric field and the spin-up and spin-down electron populations, and solve them numerically to show that this SL may behave as a spin oscillator.

In another example of semiconductor-based spintronics, a different spin oscillator can be achieved by applying a static magnetic field to a weakly

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coupled SL if at least one period contains magnetic impurities. Dr. M. Carretero (Carlos III University, Spain) and collaborators analyze and solve numerically a spatially discrete model of this system, demonstrating its behavior as an injector of spin polarized time-periodic current.

Prof. G. Platero (CSIC, Spain) discusses the use of double quantum dots as spin-current rectifiers. Quantum dots (QD) are artificial atoms, two QD separated by a barrier (double quantum dots, DQD) are artificial molecules. Attaching contacts to a DQD, electrons with a precise value of spin can tunnel through the barrier from one QD if there is an available state in the other dot and appropriate voltage bias is held between the contacts. Otherwise the Pauli principle precludes tunneling (spin-Coulomb blockade). Thus the DQD acts as a nanoscale spin rectifier, blocking current in one bias direction and allowing it in the other. Platero analyzes a simple transport model for this system and compares it to available experiments.