Electronic transport in nanostructures: Conductance fluctuations induced by a local perturbation

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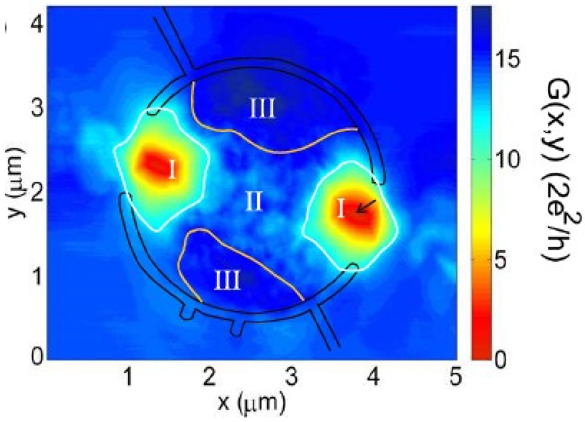

The understanding of electronic transport on the nanoscale is of great importance for the ongoing miniaturization of electronic devices. In parallel, the influence of quantum coherent processes places such a problem at the fundamentally interesting interface between classical and quantum physics. While one traditionally measures the conductance and extracts information from its dependence on parameters like temperature and applied magnetic field, the recently developed [1,2] technique of Scanning Gate Microscopy (SGM) adds spatial resolution. It consists of measuring the conductance changes induced by a local potential perturbation created by a charged AFM tip scanning the surface of the sample. The resulting maps of conductance as a function of the tip position (see the figure for an example from Ref. [3]) yield rich information including interference patterns and branches that have been interpreted as electron flow. While enormous potential for improving our understanding of quantum transport, the interpretation of the observed conductance changes in term of the local current is not obvious [4,5].

A new paradigm consists in using the SGM tip to modify the potential landscape of the system to study phase coherent transport phenomena. An example is the recent investigation of magneto-electric subbands in a sample containing a ballistic cavity [3] (the figure shows the conductance G as a function of tip position). The present project proposes to investigate theoretically how one can study quantum chaos and conductance fluctuations using SGM. When the SGM is scanned inside a ballistic cavity, one gets chaotic classical dynamics. As a consequence, the measured quantum conductance fluctuates strongly as a function of the tip position [3] (region II of the figure). We plan to study the effects of chaos on the quantum transport in this situation, with the goal to understand an analyze existing experiments as well as to predict and propose new ones.

The theoretical tools and concepts to be used are the basic ones of quantum transport through mesoscopic systems, including analytical (semiclassical expansions) and numerical (recursive Green function algorithm and classical trajectories) methods. The student will work in the Theoretical Mesoscopic Physics Team at IPCMS, in close contact with experimentalists, in particular with the group of K. Ensslin at the ETH in Zürich.

References:

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