CURRENTS IMAGING IN OPEN QUANTUM DOTS IN THE INTEGER QUANTUM HALL TRANSPORT REGIME

Alessandro Cresti
NEST-CNR-INFM and Scuola Normale Superiore
Piazza dei Cavalieri 7, I-56127 Pisa, Italy
cresti@df.unipi.it

Open dots represent a prominent class of quantum interferometers, due to their accurate realization in high mobility AlGaAs/GaAs-based two-dimensional electron gases. Experimentally, open dots have the advantages of nearly open constrictions that cancel Coulomb blockade effects; moreover the geometric width of the region where electrons flow can be easily tuned by the gate potentials.
In the integer quantum Hall transport regime, the current is supported by states located at the edges of the wire. When this current reaches the first constriction of the open dot, it is partially transmitted and partially reflected. Sailing along one edge of the dot, electrons reach the second constriction. Part of them is transmitted while the other comes back on the other edge of the dot. The path enclosed by the current inside the dot is threaded by a magnetic field and generates Aharonov-Bohm oscillations [1]. Their frequency depends on the effective area encircled by the edge states, which is in principle regulated by the gate potential, the surface electron density and the magnetic field.
In the present theoretical analysis, I simulate the above outlined phenomenology, evidencing the presence of Aharonov-Bohm oscillations (Fig.1), and providing maps of local microscopic currents (Fig.2) and local density-of-states (Fig.3). The direct visualization of the path followed by electrons allows to gain information on the flux linkage, and, at least in principles, to design properly shaped open dots.
The simulations are based on the Keldysh Green's function formalism [2], that permits to obtain the local currents, the local density-of-states and density-of-occupied-states, and the local chemical potential. I adopt the tight-binding framework in order to have an accurate description of the geometric shape of the device and of its potential profile; this choice allows us to exploit the decimation-renormalization technique [3], that greatly reduces the cumbersome numerical calculations.

References:

[1] F.E. Camino, W. Zhou, and V.J. Goldman, Phys. Rev. B, **72** (2005) 155313.

[2] A. Cresti, R. Farchioni, G. Grosso, and G. Pastori Parravicini, Phys. Rev. B, **68** (2003) 075306.

[3] G. Grosso, S. Moroni, and G. Pastori Parravicini, Phys. Rev. B, **40** (1989) 1238.

Figures:

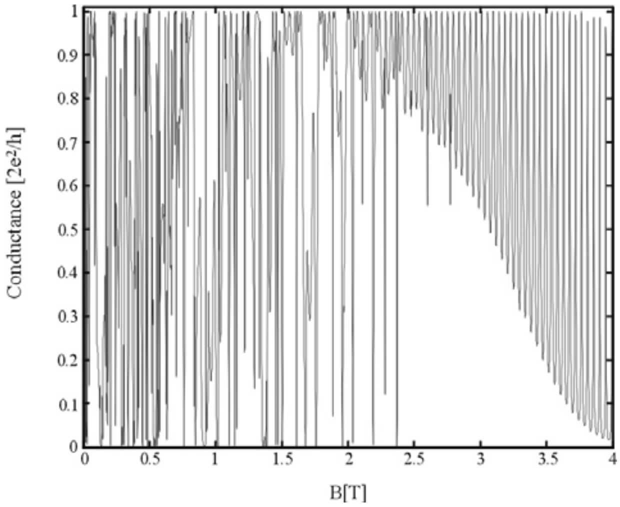

Fig.1: Conductance of the open quantum dot as a function of the magnetic field intensity, for a fixed gate potential. Notice the presence of an irregular region on the left and of a regular region with periodic Aharonov-Bohm oscillations on the right side of the figure.

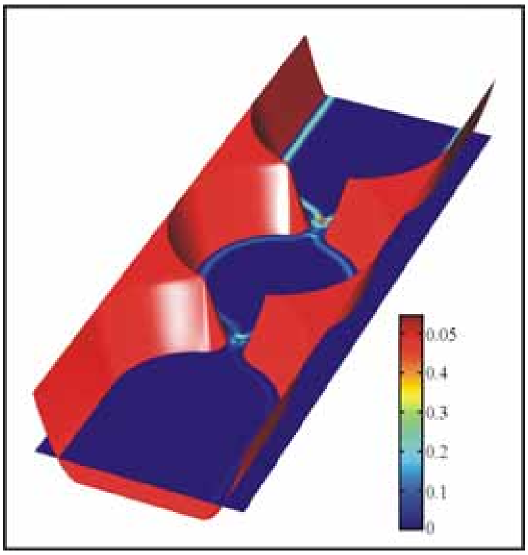

Fig.2: Map of local spectral transport currents for B=2 T. Electrons follow a closed circular path inside the dot, thus giving rise to Aharonov-Bohm oscillations. The unit on the color scale is the quantum of spectral current i_0=2e/h.

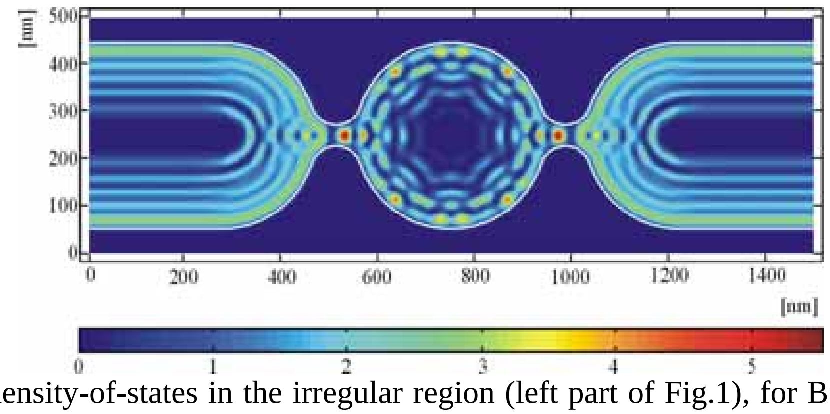

Fig.3: Local density-of-states in the irregular region (left part of Fig.1), for B=1T. Inside the open dot a spread, field dependent state is clearly visible. On the leads several edge states are present. The unit on the color scale is eV^{-1}.