

Scanning Gate Imaging of the 0.7 anomaly

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The origin of the so called “0.7 structure” in the transport characteristics of 1D mesoscopic devices represents a long standing puzzle, yet showing a continuously renewed interest for possible applications in spintronics [1]. Though several mechanisms have been proposed to explain such anomaly, a general consensus has not been achieved so far.

Among the proposed explanations are the formation of a quasi-bound state at a constriction entrance near pinch-off, quantum interference from scatterers within the electron phase coherence length from the constriction, and Kondo effect due to zero-dimensional systems inside the constriction itself acting as quantum dots. While a quasi-bound state is strictly linked to geometrical factors, being related to mode mismatch between the 1D channel and the large 2D reservoirs, the other two explanations involve the presence of point defects, such as charged impurities.

By using low temperature Scanning Gate Microscopy on GaAs/AlGaAs heterostructures in Quantum Point Contact geometry, we can definitively rule out zero-dimensional structures (e.g. charged defects and antidots) as the underlying origin of the 0.7 feature. The technique allows to identify with nanometric resolution [2] the presence of localized defects, which are detected as sharp fluctuations in the 2D charge density. On the other hand, Fig. 1(a) shows a typical SGM image of a clean QPC constriction, where the quantized conductance displays circular symmetry and no trace of charged spots is detected. Our results also weaken the hypothesis of a shallow bound state forming at the QPC entrance, because a small-amplitude local perturbation of the potential would induce charging and discharging of such a state, visible as concentric ring structures in a SGM image. As shown in Fig. 1(b), the characteristic features of the 0.7 structure survive also a strong perturbative action by the biased AFM tip, which would destroy the potential landscape and quench the quasi-bound state.

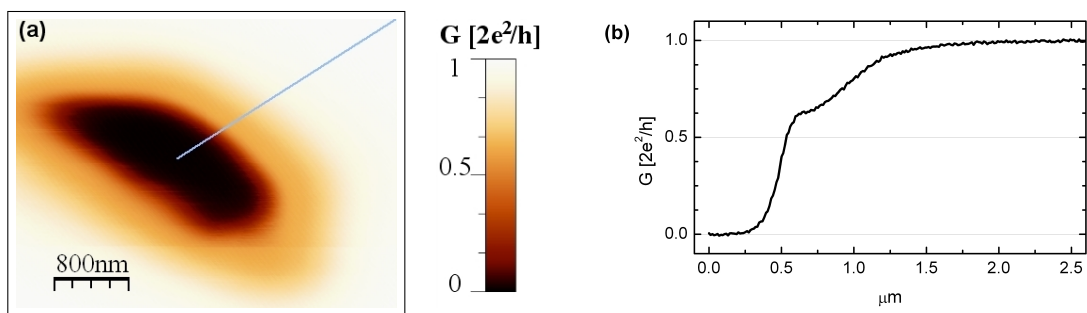


Figure 1: (a) SGM image of a QPC central region, spanning the conductance interval $0 - 2e^2/h$. A cutaway profile, obtained along the blue solid line, is shown in (b), where the plateau at $G < 2e^2/h$ is the signature of the 0.7 anomaly.

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