Revealing the energy spectrum of semiconducting nanowires by quasi-ballistic transport under high magnetic field

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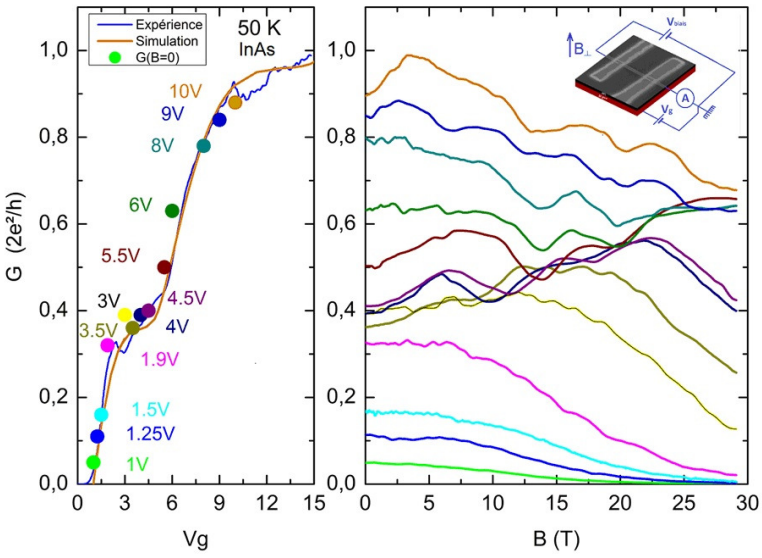
Semiconducting nanowires (sc-NWs) are subject to intense research during the last ten years. They constitute 1-D electron gases of particular interest, in a bottom-up approach, for the development of optoelectronic devices as well as for high frequency transistors and spintronics. These applications rely on the unique properties of their electronic band structures and on the control of the charge and spin dynamics. However, the band structure of individual NWs still suffers from a crucial lack of direct experimental characterization. In particular, the low band-gap of InAs makes it difficult to investigate via optic techniques. Our strategy consists in probing the DOS at the Fermi energy thanks to transport measurements performed on quasi ballistic sc-NWs based transistors under extremely large magnetic field.

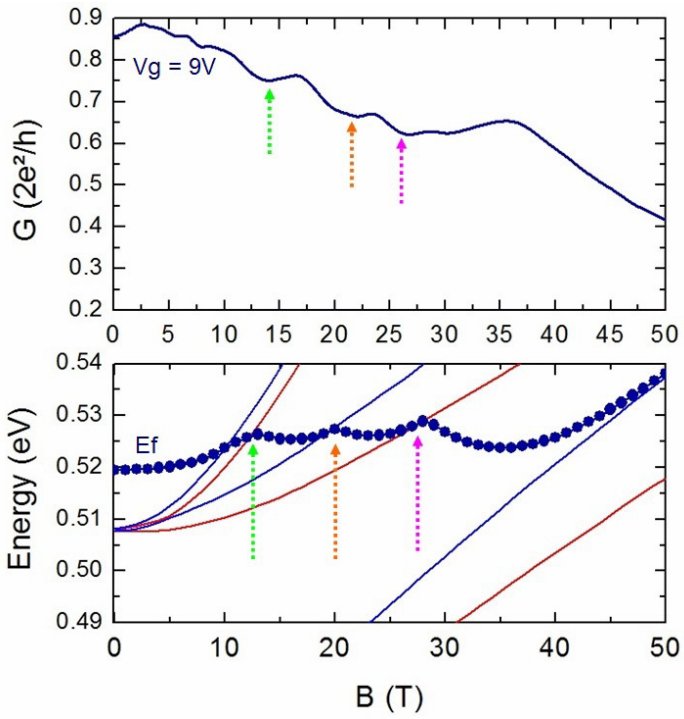
In Ballistic regime, the energy levels of the quasi-1D electron gas are revealed by the Landauer quantization of the conductance. The application of high magnetic field parallel or perpendicular to the NW induces a full spin and orbital degeneracy lifting of the energy levels accompanying with the Landau diamagnetism. As a consequence non-degenerate conductance plateaus appear in the conductance.



Left: Conductance versus gate voltage of an InAs nanowire.
Right: magneto-conductance curves at fixed gate voltage

Here, we give direct evidence of the 1D band structure of low band-gap NW on the

two-probe conductance in quasi-ballistic regime observed both as a function of the doping level and of the applied magnetic field, perpendicular or parallel to the NW axis [1]. Large magneto-conductance modulations mediated by the Fermi energy reveal the magnetic field dependence of the 1D conducting states and their spin and orbital degeneracy. Our experimental results are consistently supported by numerical simulations of the magnetic band structure, revealing the key parameters of the electronic confinement in NWs.



Top: Magneto-conductance curve for Vg=9V
Bottom: Fermi energy computation superimposed with band structure simulation

[1] F. Vigneau, V. Prudkovkiy, I. Duchemin, W. Escoffier, P. Caroff, Y. M . Niquet, R. Leturcq, M. Goiran, B. Raquet, *Magnetotransport Subband Spectroscopy in InAs Nanowires*, Phys .Rev. Lett. 112, 076801 (2014).