Charge Transport and Magneto-Electric Sub-bands in 1D Nano-Objects

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1D nano-objects like carbon nanotubes (CNT), graphene nano-ribbons (GNR) or semiconducting nanowires (sc-NWs) display remarkable electronic transport properties driven the electronic confinement at nano-scale. Their electronic band structure result in a set of 1D sub-bands with van Hove singularities in the density of states. The charge density is controlled by an electrostatic gate and a spin manipulation is envisaged in some of these materials by playing with either the spin-orbit coupling like in sc-NWs or by taking advantage of the edge states in GNR. These remarkable properties open new routes for the future of the nanoelectronics, with potential applications in the field of high frequency transistors, digital logic devices, electronic wave guides or sensors. However, a deep characterisation of the electronic band structure of an *individual* nano-object remains challenging.

In this talk, I will give experimental evidence that the electronic band structure of a single 1D nano-object can be directly addressed by electronic transport measurements, in the open quantum dot regime, and under extreme conditions of magnetic fields and temperatures. After a brief review of magneto-fingerprints of the 1D sub-bands in carbon nanotubes and in graphene nanoribbons [1], I will present recent (magneto)-transport results obtained on 30±3 nm diameters InAs NWs. At zero-magnetic field, the low temperature conductance versus a back-gate voltage, $G(V_g)$, reveals some step-like modulations, signature of the presence of van Hove singularities in the density of state. An accurate control of the number of conducting channels is therefore possible as a function of the electrostatic doping. The magneto-conductance measurements under 60T exhibit giant variations of the conductance mediated by the doping level. In particular, when only a few sub-bands participate to the electronic transport, a complete switch-off of the conductance is evidenced under both a parallel and a magnetic field. Our simulations of the electronic band structure of InAs NWs in the Landau regime (for a magnetic length smaller than the NW radius) demonstrate that the magneto-conductance behaviour brings direct signatures of the onset the magneto-electric sub-bands. The conductance switch–off in high field is assigned to the electronic depopulation. We finally speculate on the full spin polarisation of charge carriers in the lowest occupied Landau states due to the large effective g-factor.

[1] B. Lassagne & al, *Phys. Rev. Lett*. 98, 176802 (2007) ; S. Nanot & al, *C. R. Physique* 10 (2009) ; B. Raquet & al, *Phys. Rev. Lett*. 101, 046803 (2008); S. Nanot & al, *Phys. Rev. Lett*. 103, 256801 (2009); J-M Poumirol et al, *Phys. Rev. B* 82, 041413(R) (2010) ; R. Ribeiro & al., *Phys. Rev. Lett*. 107, 086601 (2011).