Quantum magnetotransport phenomena in ultra-narrow graphene ribbons

Haoliang Shen [1,2], Alessandro Cresti [3], Walter Escoffier [1], Xinran Wang [2], **Bertrand Raquet** [1]

[1] Laboratoire National des Champs Magnétiques Intenses, LNCMI-Toulouse, UPR 3228, INSA, UPS, UJF, Toulouse, France
[2] National Laboratory of Solid State Microstructures, School of Electronic Science and Engineering, Nanjing University, Nanjing, China
[3] IMEP-LAHC, UMR 5130, Grenoble INP/UJF/CNRS/Université de Savoie, Grenoble, France

Exploring the electronic confinement of Dirac fermions in graphene nanoribbons without degrading the outstanding properties of the mother material remains a delicate task for scientists. We have known, for years, that an atomic cutting of a graphene flake along a crystallographic direction gives rise to a specific electronic band structure driven by the Dirichlet boundary conditions, in close analogy with carbon nanotubes and their rolling vector. However, the often unavoidable presence of edge disorder has been shown to have a detrimental impact on the electronic structure. Only the mastering of the edge quality and orientation of sub-20nm wide graphene ribbons will allow us to fully benefit from their unusual 1D band structures, which is responsible for perfect conducting channels at low energy, spin-polarized edge states or tuneable direct band-gaps suitable for digital electronic applications.
Among the already well developed and promising techniques to synthesize high quality graphene nanoribbons (growth on SiC, anisotropic etching, catalytic nanocutting, bottom-up synthesis …), the unzipping of carbon nanotubes constitutes a reliable approach to minimize the disorder-induced transport gap around the charge neutrality point. Here, our strategy to investigate the 1D band structure of unzipped carbon nanotubes consists in using large magnetic fields to make transverse and magnetic electronic confinements compete and to detect the resulting spectrum fragmentation into magneto-electric states. In this presentation, after a brief review of the Landau magneto-fingerprints already observed in rather wide GNRs, we will focus on recent magnetotransport experiments performed under high magnetic field (62T) on a set of high quality 20nm wide bilayer-GNRs. All the experiments, including a dozen of devices, reveal an exceptionally robust $4e^2/h$ Hall conductance plateau, preceded by large magneto-conductance oscillations, which are signature of 1D sub-bands crossing the Fermi energy. Such a spectroscopy in the open quantum dot regime unveils, in a unique manner, the complex electronic band structure of the bilayer-GNRs, driven by the twisting angle between the layers and the edge chirality inherited from the mother unzipped MWCNT. These experimental fingerprints of the 1D band structure will be directly compared to band structure simulations performed for different bilayer-GNR configurations. To conclude, we will briefly address some comparative remarks on GNRs and MWCNTs, of similar width, in the presence of strong magnetic confinement.