Electron and Hole Quantum Dots in Bilayer Graphene

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Graphene and bilayer graphene (BLG) are attractive platforms for quantum electronics, quantum circuits and quantum information science in general. This has motivated substantial efforts in studying quantum dot (QD) devices based on graphene and BLG. The major challenge in this context is the missing band gap in graphene, which does not allow to electrostatically confine electrons. A widely used approach to tackle this problem was to introduce a hard-wall confinement by physical etching graphene. However, the influence of edge disorder, turned out to be a roadblock for obtaining clean and well-controlled quantum devices. The issue of edge disorder can be circumvented in clean BLG, as this material offers a tunable band gap in the presence of a perpendicularly applied electric field, a feature that allows introducing electrostatic soft confinement in BLG.

Here, I present gate-controlled single and double quantum dot operation in electrostatically gapped BLG [1-5]. I show a remarkable degree of control of our devices, which allows the implementation of gate-defined electron-hole and electron-electron double-dot systems, where single-electron occupation becomes possible [1]. Also in the single dot regime, the very few electron/hole regime has been reached, excited state energies have been extracted and their evolution in a parallel and perpendicular magnetic field has been investigated [2]. I will show data on BLG quantum dots allowing to investigate the spin-valley coupling in bilayer graphene [3], the electron-hole crossover and the high symmetry between electron and hole states [6]. Finally, I will show data on ambipolar BLG double quantum dots that allow to realize Pauli spin and valley blockade protected by particle-hole symmetry. Our work paves the way for the implementation of spin and valley-qubits in graphene.

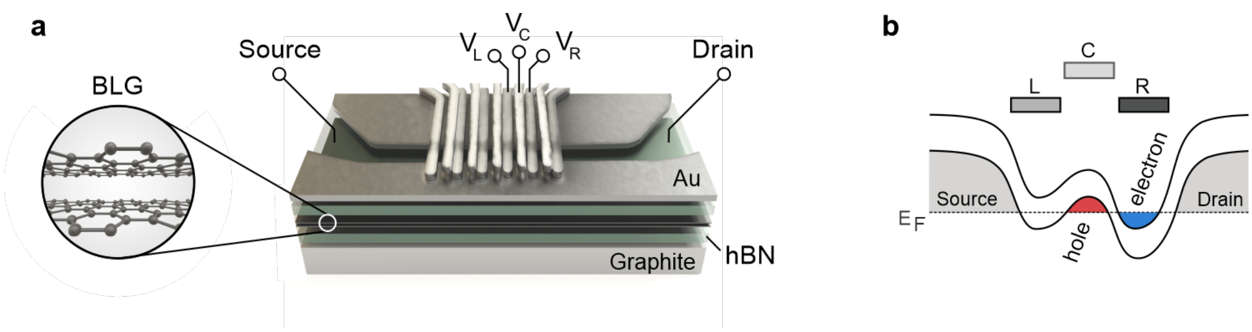

Fig.1 **(a)** Schematic cross-section of a bilayer graphene quantum dot device. **(b)** Schematic of the valence and conduction band-edge profiles along the p-type channel.

References

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