Gate-defined electron-hole double dots in bilayer graphene

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Graphene and bilayer graphene (BLG) are attractive platforms for spin qubits, thanks to their weak spin-orbit and hyperfine interaction, promising long spin-coherence times. 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 confining electrons by means of electro-statics. A widely used approach to tackle this problem was to introduce a hard-wall confinement by physically etching the graphene sheet. In this way, a number of important milestones have been reached. However, the influence of disorder, in particular the edge disorder, turned out to be a major road block for obtaining clean QDs with a controlled number of electrons/ holes and well tunable tunneling barriers.
The problem of edge disorder can be completely circumvented in BLG, thanks to the fact that this material offers a tunable band-gap in the presence of a perpendicularly applied electric field, a feature that allows introducing electrostatic confinement in BLG.
This route has been pursued by several groups to create QDs in BLG. However, until very recently, essentially all devices were limited by leakage currents due to shortcomings in opening a clean and homogeneous band gap. A very recent breakthrough in this field has been the introduction of graphite back-gates. Together with the technology of encapsulating BLG in hexagonal boron nitride (hBN), giving rise to high quality hBN-BLG-hBN heterostructures, the use of a graphite back gate allows for a homogeneous and gate tunable band gap in BLG. This technological improvement allowed for an unprecedented quality of quantized conductance measurements [1] and, most importantly, allowed realizing complete electrostatic current pinch-off. The latter finally offers the possibility of electrostatically confining carriers in BLG and to implement quantum dots with a high level of control and low disorder, as very recently demonstrated [2].
Here extend this approach and we present gate-controlled single, double, and triple dot operation in electrostatically gaped bilayer graphene [3]. We show a remarkable degree of control of our device (see Figure 1), which allows the implementation of two different gate-defined electron-hole double-dot systems with very similar energy scales. In the single dot regime, we extract excited state energies and investigate their evolution in a parallel magnetic field, which is in agreement with a Zeeman spin- splitting expected for a g-factor of two.

References

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Figure

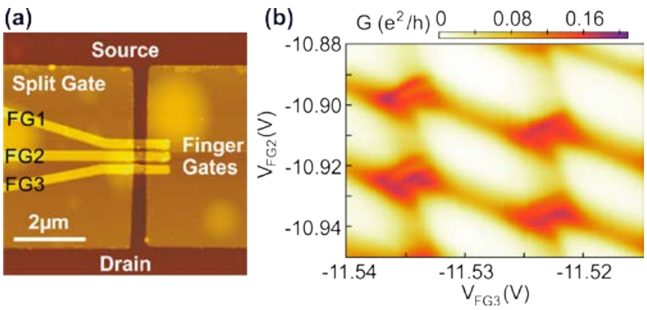

Figure 1: (a) Scanning force microscope image of a fabricated sample consisting of hBN-BLG-hBN on graphite with two layers of top gate structures. (b) Characteristic charge stability diagram of a double dot device.