Aachen Graphene & 2D Materials Center

2D Materials and Quantum Device Group | RWTH AACHEN UNIVERSITY

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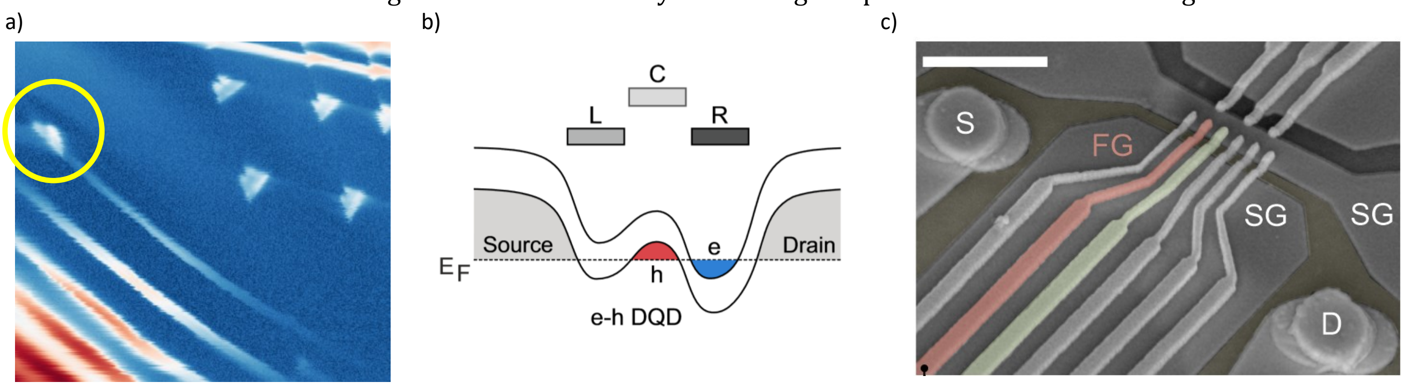
Master Thesis: Towards spin qubits in bilayer graphene quantum dots

Motivation: Research in the field of two-dimensional (2D) materials such as graphene and hexagonal boron nitride (hBN) is among the most exciting and fastest growing fields in modern solid state physics. Bilayer graphene (BLG) is especially attractive as it offers an electric field tunable band gap, low spin-orbit interaction and low hyperfine coupling, promising long spin and valley coherence times for qubit operations.
Today's technology allows the fabrication of highly tunable single and multi quantum dot (QD) devices in bilayer graphene. For qubit operation, we need a spin/valley blockade mechanism and time resolved charge detection. We already observed different blockaded regimes and are currently fabricating samples for time resolved charge detection.



a) Transport measurement of two coupled quantum dots. The triple point structure shows electron transport, the diagonal lines show hole transport. (b) Schematic of the band edges with respect to the Fermi energy along the conducting channel from source (S) to Drain (D), showing the creation of an electron-hole double QD (yellow circle) (c) SEM Image of a sample for charge detection with two parallel channels for main QD and the sensing QD, electrostatically defined by the split gates and finger gates.

Aim of the thesis: *The goal of your thesis is to investigate mechanisms to manipulate quantum states by means of* electron dipole spin resonance *(EDSR) in different blocked regimes in a bilayer graphene double quantum dot, aiming to identify the most suitable regime for creating a qubit.*

Your tasks: You will contribute to the fabrication, measurement and evaluation of bilayer graphene quantum dot samples. You are free to choose on which topic to focus on. The fabrication includes working in a clean room environment, characterizing samples with tools like Raman spectroscopy or atomic force microscopy, and designing masks for electron beam lithography. We perform transport measurements in a dry dilution refrigerator at a base temperature of 10mK and evaluate most of our data with python.

You will gain experience in the following topics:

- Quantum physics, electronic bandstructures, quantum dots
- Fabrication of state-of-the-art quantum devices
    - Clean Room Experience
    - Spectroscopy Tools like Raman, AFM
    - Electron-beam lithography
- Performing measurements on a dilution refrigerator
- Data evaluation and simulations with *Python* or *Mathematica*

Furthermore, you take part in group seminars and journal clubs where you follow current developments in this field of research and discuss recent experiments.

Contact: For further information, pleases contact Samuel Möller (samuel.moeller@rwth-aachen.de) or Katrin Hecker (katrin.hecker@rwth-aachen.de). More information about our work can be found at stampferlab.org and www.graphene.ac.