Aachen Graphene & 2D Materials Center

2D Materials and Quantum Device Group

RWTH AACHEN UNIVERSITY

Master Thesis:
Probing band structure anisotropy via quantum dot spectroscopy

Motivation: The effective mass of a charge carrier in a solid is commonly used to reduce a material's band structure to a simple model with a single constant value, or a constant tensor for anisotropic bands. This approximation enables the extraction of quantitative parameters from experiments, including carrier mobility, confinement energies, and the density of states near the band edge.

This model breaks down when the band dispersion deviates from a purely parabolic form and higher-order terms in the wave vector become relevant. In bilayer graphene (BLG), for example, the effective mass tensor becomes wave-vector dependent in two dimensions. Moreover, the effective mass depends on the band gap size and can be tuned by the displacement field applied between the two graphene layers in the heterostructure. One way to probe these effects is to examine the energy spectrum of differently oriented quantum dots.

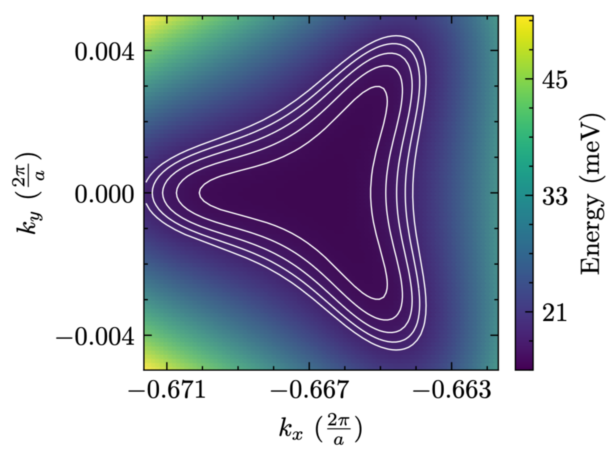
Aim of this thesis: *The goal of this thesis is to design and realize a device platform that allows systematic investigation of how the orientation of an electrostatic confinement potential affects the quantum-dot energy spectrum. This will provide insight into the BLG band structure under confinement and its anisotropic and field-tunable properties.*

Your tasks: You will fabricate bilayer graphene heterostructures in a cleanroom using exfoliation and dry transfer. Further device processing will include electron-beam lithography, metal evaporation, and atomic layer deposition and/or etching. You will then perform low-temperature electronic transport measurements down to 20 mK and analyze the resulting data using self-developed analysis scripts, preferably in Python.

You will gain experience in the following topics:

- Quantum dot physics, electronic transport, 2D-material based quantum dots
- Fabrication of state-of-the-art quantum devices
- Performing measurements in a dilution refrigerator
- Data evaluation using self-developed code

Furthermore, you participate in group seminars and journal clubs, where you follow current developments in the field and discuss recent experiments.



calculated isosurfaces of the BLG conduction band for a band gap of 30 meV. White lines show some isosurface contours for better visibility.

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More information about our work can be found at stampferlab.org and www.graphene.ac