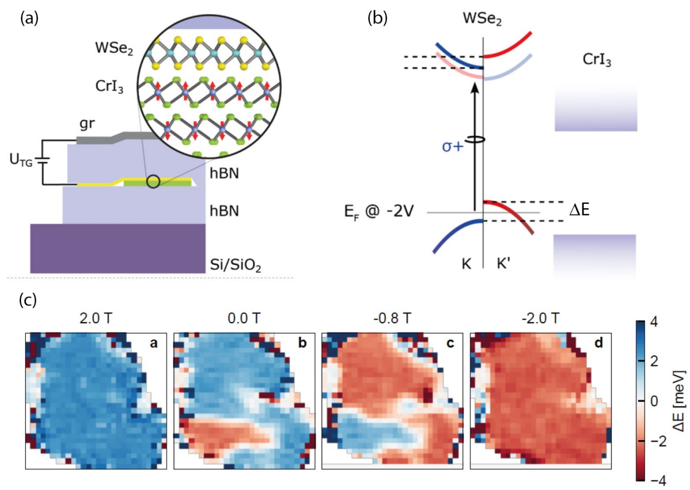
Aachen Graphene & 2D Materials Center

2D Materials and Quantum Device Group | RWTH AACHEN UNIVERSITY

Master thesis:
Valley Dynamics and Magnetic Proximity in WSe_2/CrI_3 Heterostructures

Motivation: Valleytronics explores the use of the valley degree of freedom in two-dimensional semiconductors for future electronic applications. Monolayer WSe_2 is a promising candidate due to its strong spin-valley locking and valley-selective optical transitions. When WSe_2 is coupled to a 2D magnet like CrI_3, magnetic proximity effects can induce significant valley splitting without external magnetic fields. These effects can be dynamically controlled via gate voltages and optical excitation. They offer new ways to manipulate valley polarization and spin information at the nanoscale.



(a) Schematic of the device structure, where WSe_2 is proximity-coupled to a CrI_3 layer. (b) The magnetic proximity effect from CrI_3 induces spin splitting in the band structure of WSe_2. (c) This spin (or valley) splitting can be spatially resolved using magnetic-field-dependent optical spectroscopy, specifically through magnetic circular dichroism (MCD).

Goal of thesis: In this thesis, you will investigate the ultrafast valley dynamics in WSe_2/CrI_3 heterostructures using time-resolved Kerr rotation spectroscopy. Our preliminary results show that the spin-polarized transfer of carriers from CrI_3 into WSe_2 generates valley polarization with ultralong lifetimes exceeding 80 ns, and that these dynamics can be tuned via electrostatic gating. This work is embedded in our ongoing fundamental research on spin and valley physics in 2D materials.

Your task:
Your responsibilities will include the fabrication and characterization of 2D heterostructures as well as optical measurements using pump-probe setups. You will perform:

- Exfoliation and stacking of 2D materials (WSe_2, CrI_3, hBN) in an inert atmosphere
- Device fabrication using lithography and metal deposition
- Optical spectroscopy including time-resolved Kerr rotation and magnetic circular dichroism (MCD)
- Analysis of valley polarization dynamics under varying gate voltages and excitation conditions

You will also deepen your understanding in:

- Ultrafast optical spectroscopy and valley dynamics in 2D materials
- Spin and valley physics, excitons, and proximity effects
- Cryogenic measurement setups (~5 K)
- Microscopy-based flake selection and automated flake detection algorithms

Furthermore, you will participate in group seminars and journal clubs to discuss current developments in this research field.

Contact: For further information and interest in the project, please contact Bernd Beschoten (bernd.beschoten@physik.rwth-aachen.de). More information about our work can also be found at www.stampferlab.org.