Institut für Angewandte Physik

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UNIVERSITÄT BONN

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COLLOQUIUM „OPTICS AND CONDENSED MATTER“

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CIC nanoGUNE, San Sebastian, Spain

“Nanoscale optical properties of two-dimensional materials”

Thin layers of transition metal dichalcogenide (TMDC) are a new class of two-dimensional semiconductors with outstanding physical properties. They show bright photoluminescence and are extremely flexible. Strain strongly modifies the electronic band structure and the fundamental optical transitions, i.e., excitons, leading to an energetic shift of the exciton resonances and the modification of the exciton-phonon interaction [1,2]. In addition, strain can be used to create single photon emitters (SPEs) in these materials at low temperatures [3]. SPEs also naturally occur in hexagonal boron nitride (hBN) in a wide energy range [4] even up to room temperature, making them promising candidates for future quantum technologies. Interestingly,
their atomic defect structure is still under debate.
The possibility to combine different 2D materials opens the opportunity to create designed optical properties. Furthermore, the combination of two slightly misaligned crystal lattices results in a super-lattice structure, the so-called moiré lattice, leading to spatially varying excitonic properties on the range of several tens of nanometers.

In order to investigate the optical properties on the nanoscale one has to overcome the diffraction limit of light. Near-field techniques (such as s-SNOM and nano-FTIR as well as TEPL and TERS) are based on atomic force microscopy and allow to measure the local optical and phononic properties with a resolution of ~ 30 nm.

In my talk I will present my past research on manipulating the optical properties of mono- and bilayers of TMDCs by deterministic application of strain, as well as my current research using near-field techniques like s-SNOM and TEPL/TERS on the same material class. In addition, I will briey sketch my ideas for future research projects.

[1] I. Niehues, R. Schmidt, et al., Nano Lett. 18, 1751 (2018).
[2] I. Niehues, P. Marauhn, et al., Nanoscale 12, 20786 (2020).
[3] J. Kern, I. Niehues, et al., Adv. Mater. 28, 7101(2016).
[4] S. Michaelis de Vasconcellos, D. Wigger, et al., Phys. Status Solidi B 259, 2100566 (2022).

December 6 th, ZOOM ONLY
https://uni-bonn.zoom.us/j/98441612025?pwd=a01SSjlkY1Q3SDFhL09JQk1qc1V6dz09
Meeting-ID: 984 4161 2025
Kenncode: 294164