Light matter interaction and many-body physics in 2D materials

Ursula Wurstbauer

Institute of Physics, University of Münster, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany

Important for all (quantum) optical technologies is the manipulation of the light-matter interaction to achieve a high level of control, particularly in technologically relevant solid-state nanomaterials. Atomically thin two-dimensional layered materials receive great interest because of their unique properties. A novel class of atomically thin materials, 2D polar metals such as 2D gallium or 2D indium exhibit fascinating properties like superconductivity [1] strong nonlinear optical properties emerging by giant second harmonic generation [2] and epsilon near zero behavior in the visible and NIR range [3]. In contrast, monolayers of semiconducting transition metal dichalcogenides (SC-TMDCs) excel due to their strong exciton dominated light matter interaction [4]. VdW heterobilayers prepared from SC-TMDCs are ideal systems for the realization of exciton condensation because of large exciton binding energies, long lifetimes [5] and a permanent dipole allowing for the manipulation of the exciton ensembles via electric fields [6] or the deterministic integration of functional sites acting as quantum light sources [7]. We will discuss recent developments in the area of multi-valley physics and condensation signatures in TMDC hetero-bilayers [8-10]. Furthermore, we will introduce a rather new class of 2D materials, 2D polar metals and focus on their linear optical response measured by spectroscopic ellipsometry.

This work is done in close collaboration with Lukas Sigl, Florian Sigger, Mirco True, Katharina Nisi, Shruti Subramanian, Wen He, Su Ying Quek, and Joshua A. Robinson and Alexander Holleitner. We acknowledge funding by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under Germany´s Excellence Strategy – EXC 2089/1 – 390776260 and projects Wu 637/4- 1, 4 – 2, 7-1 and SPP 2244.

References

[1] N. Briggs et al. Nature Materials 19 (6), 637-643 (2020).
[2] M. A. Steves et al. Nano Letters 20, 11, 8312–8318 (2020).
[3] K. Nisi et al. Advanced Functional Materials 2005977, 1-11 (2020)
[4] U. Wurstbauer et al. J. Phys. D: Appl. Phys. 50 (2017)
[5] B. Miller, et al., Nano Lett. 17(9), 5229–5237 (2017).
[6] J. Kiemle et al. Phys. Rev. B 101, 121404(R) (2020).
[7] J. Klein et al. ACS Photonics 8, 2, 669–677 (2021).
[8] A. Kogar, et al. Science 358, 1314 (2017).
[9] Z. Wang, et al. Nature 574, 76 (2019).
[10] L. SIgl et al. Physical Review Research 2, 042044(R) (2020)