Semiconducting 2D crystals and their heterostructures

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The (re-)discovery of graphene in 2004 by Geim and Novoselov [1] was hour of birth to the vibrant interdisciplinary research area of 2D materials. Any van-der Waals layered material can be split into single- and few layers with often superior characteristics compared to the three dimensional crystal. The talk will mainly focus on transition metal dichalcogenides (TMDs) [2], where a monolayer consists of a transition metal surrounded by two chalcogen atoms. Semiconducting TMDs such as MoS$_2$ or WSe$_2$ are of current interest for optoelectronic, sensing and energy harvesting applications, but also for studying fundamental aspects of light-matter interaction dominated by a high exciton binding energy in the order of 500 meV [2].

TMDs provide a high sun light absorbance of up to 15% in the monolayer limit, photocatalytic stability, HER activity, strong photocurrent response, environmental sensing capabilities [3-7]. I will discuss the robustness of the fascinating spin- and valley properties against defects induced by a focused helium ion beam and introduce Raman measurements as a versatile, non-destructive and contactless probe to particularly study charge carrier density, defect concentration and strain [2-8].

In the last part of the talk, I will discuss van der Waals heterostructures - a novel platform for tailored heterostructures without the limitations of lattice mismatch. We have recently demonstrated that MoSe$_2$/WSe$_2$ monolayers host long-lived momentum direct and indirect interlayer excitons making those structures an interesting material system to study many-body phenomena of composite bosons at elevated temperatures [9].

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