WWU MÜNSTER

Aktuelle Fragen der Nanophysik

Montag, 17.04.2023 um 15:15 Uhr
R87, Wilhelm-Klemm-Str. 10

Valley and exciton physics in van der Waals heterostructures

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Two-dimensional (2D) transition metal dichalcogenides (TMDs) are attractive systems for studying the physics of spin-valley coupling and excitonic effects. Particularly, strong Coulomb interaction in monolayer (ML) TMDs results in the formation of different excitonic complexes involving electrons and holes in the conduction (CB) and valence (VB) bands of the K and K´ valleys. Under external perpendicular magnetic field, interesting phenomena can be observed such as valley Zeeman splitting and magnetic-field-induced valley polarization. The exciton physics becomes even richer when they are vertically stacked to form twisted van der Waals (vdW) heterostructures. These heterostructures exhibit periodic variations, leading to a new type of in-plane superlattice known as moiré superlattice/pattern which modifies considerably the optical and magneto-optical properties of excitons in TMD vdW heterostructures. In most of them, the strong Coulomb interaction in these materials gives rise in the formation of interlayer moiré excitons (IEs) with electrons and holes located in different TMD layers. Furthermore, there are also vdW heterostructures where the carrier wavefunctions are distributed over both layers and these excitons are referred to as hybrid excitons. In this talk, I will present our recent efforts to understand the impact of smooth/local strain, doping and moiré pattern on the valley and exciton physics of van der Waals heterostructures.