WWU MÜNSTER

Aktuelle Fragen der Nanophysik

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Online Seminar

Bright and dark excitons in transition metal dichalcogenides (TMD) and their heterostructures

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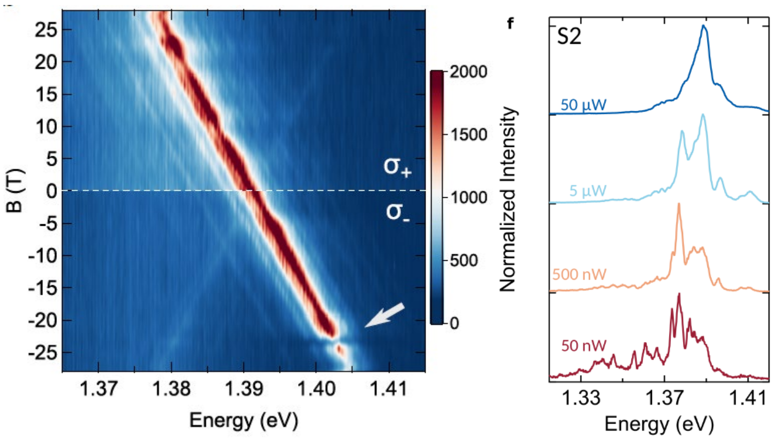
I will present an overview of the research performed at LNCMI-Grenoble on monolayers of TMD and of their heterostructures. Monolayers of semiconducting transition metal dichalcogenides are direct band gap semiconductors for which the direct band gap is located in the two inequivalent K and K' valleys [1]. Optical properties of TMDs are imposed by the conservation of the total angular momentum. They host different type of excitons, bright excitons that couple to light and propagates perpendicularly to the layer plane, and the so-called dark excitons, which propagates within the plane of the layers. The first part of the talk will be dedicated to the description of optical properties of bright and dark excitons in monolayers of TMD encapsulated in hexagonal boron nitride. I will show how to image dark excitons and how can we probe their properties experimentally [2]. Monolayers can be stacked on top of one another in the form of van der Waals heterostructures to create artificial heterobilayers that can host interlayer excitons for which electrons and holes are in different layers. Recently, it was realized that the twist angle between the two layers can strongly modify the electronic properties of the stack and can also be used to generate a lateral modulation of the potential through a moiré pattern. In a second part, I will describe optical properties of a $WSe_2/MoSe_2$ heterobilayer in which the two layers have been aligned with an angle close to 60° (2H stacking) to create a well-defined band structure together with a moiré potential. The conservation of the total angular momentum in these heterostructures leads to a very specific and efficient electron-phonon interaction, when the phonons involved are chiral and carry an angular momentum. I will show how these particular structures, combined with the use of high magnetic fields (see figure), allow for a rich spectroscopy of interlayer exciton scattering mechanism [3].



[1] Koperski et al. Nanophotonics 6, 1289, (2017)
[2] Molas et al., Phys. Rev. Lett. 123, 136801, (2021)
[3] Delhomme et al. 2D Materials 7, 041002, (2020)