Seminarankündigung

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"Coherence of excitons in $MoSe_2$ monolayers"

Optical spectra of semiconductors display narrow resonances below the absorption edge, which are attributed to the **excitons**, i.e. Coulomb correlated excitations of electrons and holes. When shining laser light onto a semiconductor, the induced excitonic polarization collectively oscillates in phase - this phenomenon is known as the exciton **coherence**. The coherence decays in time owing to various ultrafast processes occurring in a solid: radiative and nonradiative decays, scattering with carriers and phonons.

Over the last 15 years, by employing tools of nonlinear spectroscopy, I have been exploring coherent dynamics and control of excitons in various semiconductor nanostructures. In this talk however, I will focus on MoSe2, which is an iconic material from the family of semiconducting transition metal dichalcogenides. In a monolayer form, which can be obtained either via mechanical exfoliation or the epitaxial growth, MoSe2 hosts robust excitons of enhanced binding energy and high oscillator strength. Owing to the strong Coulomb interactions, they can generate giant optical nonlinearities, like harmonic generation series and wave-mixing responses [1, 2].

I will explain how nonlinear spectroscopy, which retrieves such responses, permits us to accurately assess homogeneous and inhomogeneous broadenings from the spectral line width in a presence of disorder. I will then argue that, owing to the exciton localization via disorder, these quantities are anti-correlated [3]. Next, I will show that with nonlinear spectroscopy one can monitor the crossover from the disordered toward 'clean' samples [4].

Recently, such 'clean' samples enabled observation of the Wigner crystal state [5] and the optical sensing of quantum Hall effect in graphene [6]: both are landmark achievements in the field of strongly correlated electron systems. In that context, it is relevant to ascertain the influence of the free electron density on the exciton line width. In the last part of the talk, I will therefore discuss the exciton coherence and population dynamics in a more advanced hBN/MoSe2/hBN electrostatically gated device. Finally, by performing two-dimensional spectroscopy I will illustrate that the coupling of different exciton species can be controlled with the gate voltage [7]. These findings brings new fundamental insights into the optoelectronics of MoSe2.

The talk will be concluded by pointing out novel research avenues emerging thanks to the ongoing collaboration with the Walter Schottky Institute.

[1] T. Jakubczyk et al. Nano Lett. 16, 5333 (2016)
[2] T. Hahn et al. Adv. Sci. 9, 2103813 (2022)
[3] T. Jakubczyk et al. ACS Nano 13, 3500 (2019)
[4] C. Boule et al. Phys. Rev. Materials 4, 034001 (2020)
[5] T. Smole´nski et al. Nature 595, 53 (2021)
[6] A.Popert et al. https://arxiv.org/abs/2111.12887
[7] A. Rodek et al. Nano Lett., under review

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