Physikalisches Kolloquium

Einladung

Physics Colloquium

Invitation

Monday, 22 April 2024

BE AWARE - ROOM CHANGE - Lecture Hall O25/H2, at 16:15
Coffee and cookies will be served in front of the lecture hall from 16:00

Investigating atomically thin materials with the world's largest magnets

Dr. Andreas V. Stier

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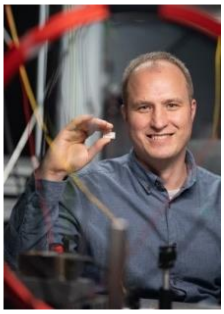
https://www.wsi.tum.de/views/user.php?user=180113319



Optical spectroscopy in high magnetic fields has historically played an essential role in determining the fundamental properties of excitons (mass, size, binding energy (E_B) etc.). In conventional bulk semiconductors such as GaAs, or CuO_2, magnetic fields ~ 10T are sufficient to achieve the regime where cyclotron energies exceed E_B. In marked contrast, in the family of monolayer semiconductors such as MoS_2, WSe_2 or 2D perovskites, masses are heavier and E_B is huge, requiring magnetic fields of order 100 T to reach this regime [1,2,3].
In this talk, I will review our recent progress on magneto optical spectroscopy of laterally small and atomically thin materials in magnetic fields up to 91 T with an emphasis on the spin-valley physics of neutral and charged excitons. In monolayer semiconductors at charge neutrality, high field magneto-spectroscopy revealed the diamagnetic shifts of the exciton Rydberg states [2,3], which allowed the first direct experimental measure of the excitons reduced mass and binding energy.
These studies aided our understanding of Coulomb interactions in 2D semiconductors.
In gated structures, at excess electron-or hole doping, we examine the interaction of the exciton with the surrounding Fermi sea. For hole doping, we observe spontaneous valley polarization, reminiscent of a magnetic phase transition [4]. For electron doped MoS_2, we find that the electron spin of the resident electron bath defines the exciton spin and ground state of the dressed exciton [5,6].
These results cannot be understood within a single-particle picture, highlighting the importance of exchange interactions and intervalley correlations for 2D excitons.
For heterostructures of a 2D semiconductor with graphene, we find a new multi-step proximity effect due to the crystalline nature of the stacked materials, where we show that careful investigation of the spin-valley physics can be used as a tool to quantify interlayer hybridization [7].
Lastly, I will show how high field spectroscopy revealed the intricate level structure of deterministically formed single atomic defects in 2D materials [8], which constitutes the ultimate limit of nanotechnology. We show how excitonic effects must be taken into account in order to understand quantum emitters in 2D materials, a result of importance for the field of quantum sensing and technology.

[1] A.V. Stier et al., Nature Comm. 7, 10643 (2016)
[2] A.V. Stier et al., Phys. Rev. Lett 120, 057405 (2018)
[3] M. Goryca et al., Nature Comm. 10, 1 (2019)
[4] J. Li et al., Phys. Rev. Lett. 125, 147602 (2020)
[5] J. Klein et al., Phys. Rev. R. 3, L022009 (2021)
[6] J. Klein et al., Phys. Rev. B,105, L041302 (2022)
[7] P. E. F. Junior et al., 2D Materials 10, 034002 (2023)
[8] A. Hötger et al., npj 2D Mat. and Appl., 7, 30 (2023)

Host: Prof. Dr. Johannes Hecker Denschlag, Institute of Quantum Matter

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