Universität Münster

Aktuelle Fragen der Nanophysik

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R87, Wilhelm-Klemm-Str. 10

Charge and Spin Dynamics in 2D TMDs: Substrate and Magnetic Field Effects

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Two-dimensional (2D) layered materials have emerged as one of the most promising platforms in solid-state physics, offering a wide range of nanoscale physical phenomena relevant to both fundamental studies and technological applications. Among them, semiconducting transition metal dichalcogenides (TMDs) stand out due to their direct bandgap and robust excitonic properties. Their strong spin-orbit coupling also enables rich spin-related physics, making them attractive for applications in fields like opto-spintronics. Additionally, their low dimensionality and easy stacking nature allow for versatile control of their properties through combining them with other materials and external fields.

In this talk, I will present two case studies demonstrating how the charge and spin dynamics of monolayer TMDs can be tuned via substrate interaction and external magnetic fields. In the first case, I will discuss how the charge dynamics of monolayer WSe_2 is modified when in contact with a gallium arsenide (GaAs) substrate. Using the optical pump-probe technique, I will show how interfacial charge transfer leads to exciton dissociation and altered relaxation pathways [1]. In the second case, I will present how spin dynamics in monolayer $MoSe_2$ behaves under high magnetic fields applied perpendicular to the sample plane. We find that the field effectively modulates spin dynamics, consistent with rapid hole transfer between valley states [2]. These results offer insights into the role of the environment and external fields in governing charge and spin behavior in 2D semiconductors, highlighting their potential for future device applications.

[1] Rojas-Lopez, R. R., Hendriks, F., van der Wal, C. H., Guimarães, P. S. S., & Guimarães, M. H. D. (2024). Charge dynamics in the 2D/3D semiconductor heterostructure WSe_2/GaAs. Applied Physics Letters, 125(13).

[2] Rojas-Lopez, R. R., Hendriks, F., van der Wal, C. H., Guimarães, P. S. S., & Guimarães, M. H. D. (2023). Magnetic field control of light-induced spin accumulation in monolayer $MoSe_2$. 2D Materials, 10(3), 035013.