Experimentelle Physik 2

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Exploring Spin Diffusion Dynamics: Unveiling the Spin-Orbit Interaction in Semiconductors

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Spintronics aims to uncover and leverage the intricate interplay between electron charge and spin. Notably, the field has celebrated both scientific and commercial triumphs, exemplified by the Nobel Prize awarded in 2007 for the discovery of magnetoresistance, a breakthrough subsequently employed in hard disk drives. While certain spintronics applications have reached commercial maturity, the discipline remains a fertile ground for exploring new physics with fundamental implications and promising practical applications.

These advancements in spintronics are largely propelled by the profound impact of strong spin-orbit coupling. Among the sophisticated tools utilized to investigate spin-orbit coupling, time and spatial resolved magneto-optical Kerr effect microscopy stand out as powerful yet intricate instruments. It enables the monitoring of spin polarization evolution over time and space, facilitating the establishment of correlations between spin diffusion, spin lifetime, electron density, and more, in both low-dimensional and bulk semiconductors.

The forthcoming discussion will primarily delve into two focal points: the Persistent Spin Helix (PSH) phenomenon observed in non-centrosymmetric two-dimensional semiconductors, and the spin diffusion dynamics of free "hot" excitons in bulk lead halide perovskites. In the exploration of PSH, it becomes evident that despite decades of research into the fundamental properties of conventional semiconductors like GaAs, intriguing new phenomena await discovery and scrutiny [1-3]. Conversely, the flourishing field of perovskites, fueled by their remarkable photovoltaic and opto-electronic properties, reveals a conspicuous gap in our understanding of their fundamental behaviors [4]. A pivotal process that intertwines these realms is the diffusion of spin-polarized particles, underscoring the essential quest to comprehend the interaction of spin motion with the surrounding environment.

[1] S. Anghel et al., Spin helices in GaAs quantum wells: Interplay of electron density, spin diffusion, and spin lifetime, *J. Appl. Phys.* **132**, 054301 (2022).
[2] S. Anghel et al., Anisotropic expansion of drifting spin helices in GaAs quantum wells *Phys. Rev. B*, **103**, 035429 (2021).
[3] S. Anghel et al., Spin-locked transport in a two-dimensional electron gas *Phys. Rev. B* **101**, 155414 (2020).
[4] S. Anghel et al., Fast diffusion of spin polarized excitons in organic–inorganic lead halide perovskites, *ACS Photonics* **10**, 4169 (2023).