Dynamics of excitons in semiconductors

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Coulomb bound electron-hole pairs, i.e. excitons, form the most fundamental many-body correlation in semiconductor materials and strongly affect their optical and electrical properties. Consequently, excitons are of great interest for theoretical and experimental physicists. With the development of short-pulsed lasers and ultrafast detection techniques in the picosecond and subpicosecond range, researchers focused on dynamic features of these quasiparticles. However, these investigations were usually based on optical spectroscopy such as time-resolved photoluminescence. Those optical methods suffered a severe setback in 1998 when Kira et al. showed theoretically that they are not suitable to investigate excitons and their dynamics. Instead, optical pump-terahertz probe spectroscopy should finally provide unambiguous insights into the formation dynamics of an exciton population as it detects their internal transitions.

Here, terahertz spectroscopy is utilized to reveal the conditions for and the dynamics of exciton formation out of an unbound electron-hole plasma in semiconductors and semiconductor heterostructures. In this context, the question of whether terahertz spectroscopy really provides such unambiguous insights into the exciton formation is explored. Furthermore, the coherent and incoherent dynamics of spatially separated electron-hole pairs in semiconductor heterostructures with a type-II band alignment are analyzed. Additionally, I will discuss the spectral properties of excitonic resonances in such type-II heterostructures, the linewidth of which can be narrowed by an optical excitation.

Finally, an experimental approach based on terahertz spectroscopy to extend our understanding of complex interactions in many-body systems is presented.

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