# Quantum Theory for Local Excitations in Semiconductor Nanostructures (AGSR_61)

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The ongoing miniaturization of electronic and optoelectronic devices can reveal the quantum nature of matter and lead to deviations from classical behavior. At the same time, the extraordinary properties of excitons (for example their large absorbance) can be directly utilized in optoelectronic devices. Any systematic design of such nanostructure devices requires a detailed description of the fundamental quantum processes including formation, interaction, and transport of carriers, excitons, and other quasiparticles. We present a new microscopic theory that extends established theories to describe homogeneous excitations of semiconductors (the semiconductor Bloch equations), to also include spatial inhomogeneities that occur in semiconductor nanostructures.

As a proof of principle, we apply it to study an experiment where a gallium arsenide quantum-well sample is excited by an ultrafast and tightly focused laser pulse. A second time delayed pulse that is also scanned across the optically excited region is used to study the excitation dynamics with spatial and temporal resolution. Figure 1 shows the change of the excitation spot size as a function of time that can be extracted from the measurement. An unexpected transient decrease of the spot size by about 2% can be observed, before the dynamics transitions into a diffusive expansion. Our theory quantitatively explains this phenomenon and identifies that the effect stems from the conversion of polarization to incoherent excitons as well as excitation induced shifts in the system. As an outlook, our new approach can be extended to study localized quantum optoelectronic excitations in semiconductor nanostructures.

In conclusion, we have developed a new approach to describe spatially localized excitations in semiconductor nanostructures and applied it successfully to explain the surprising experimental observation of a narrowing excitation spot size.

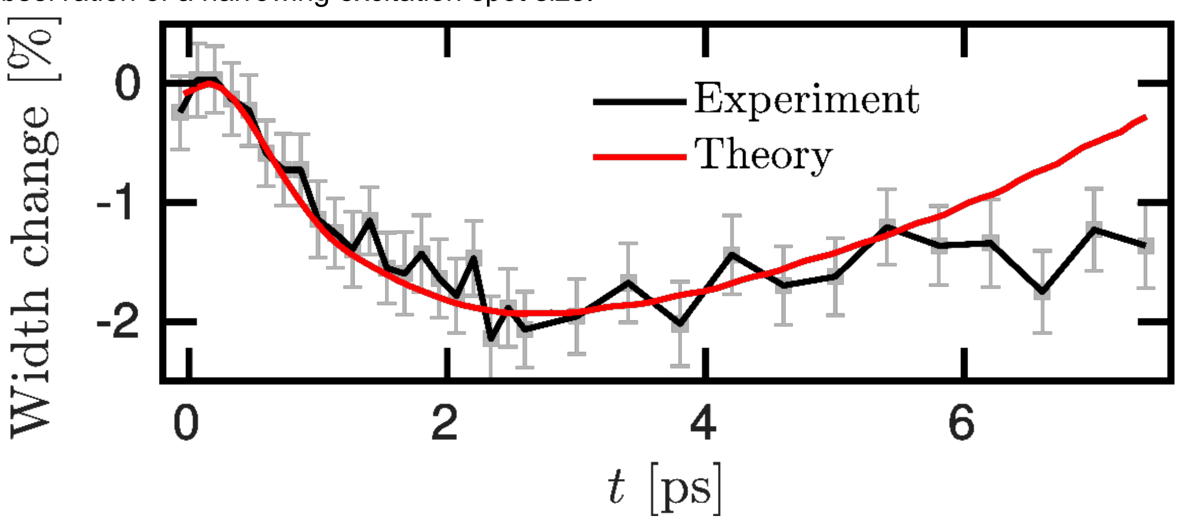


**Figure 2**: Change of excitation spot width after local excitation of a GaAs quantum well sample with a 600 nm wide pump spot. Theoretical calculation in red, experimental measurement in black with error bars.