Exciton-Bloch-Equation Approach to Study the Competition Between Exciton-Exciton and Exciton-Light Interaction

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Semiconductor quantum wells and atomically thin semiconductors constitute a remarkable playground for exciton physics in two dimensions. Due to the different dielectric screening of the Coulomb potential in both nanostructures, the binding energies of the corresponding excitons differ by more than an order of magnitude. This situation allows to compare the competition of exciton-exciton and exciton-light interaction in different regimes: For typical field strengths in non-linear optical experiments, exciton-exciton interaction dominates the dynamics in atomically thin semiconductors, whereas exciton-light interaction is more pronounced in conventional quantum well structures.

In this contribution, we develop an exciton-Bloch-equation approach to theoretically describe resonant and ultrafast non-linear optical phenomena such as Rabi oscillations and -splitting in an interacting exciton gas. Differences in the optical response, as shown exemplarily in Figure 1 below, are traced back to the different strength of many-particle exciton-biexciton transitions at different ratios of Rabi- and excitonic binding energy.

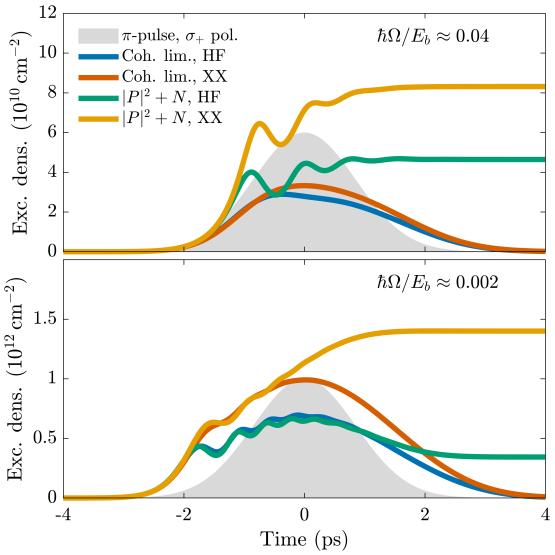

Figure 1: 1s exciton dynamics for two different ratios of peak Rabi energy $\hbar\Omega$ vs. excitonic binding energy E_b in the coherent limit (blue and red lines) and for the combined coherent and incoherent dynamics (green and yellow lines). "HF": Hartree-Fock mean-field contributions, "XX": many-particle exciton-exciton correlations.

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