

We investigate the exciton-biexciton dynamics in a spherical InAs nanocrystal. In order to increase the photovoltaic conversion efficiency, we basically focus on the utilization of novel nano-structures, such as quantum wells, quantum dots or graphene systems as candidates of advanced materials. The quantum effects in such nano-structures influence highly the carrier dynamics and enable new processes which are not possible by using bulk materials. In the first part of the talk, the general population dynamics of the single- and bi-exciton states in semiconductor nanocrystals will be explored. This study is in the presence of the Coulomb coupling between the single- and two-exciton states and a dissipation channel in order to study the transient bi-exciton population which normally occurs in an optically excited semiconductor nano-crystal.

Afterwards, the matrix elements of the Coulomb interaction between states with different number of the electrons and holes in a semiconductor are derived within the eight-band k.p theory. These matrix elements are responsible for the multiple excitons generation which may contribute to the enhancement of the efficiency of solar cells.

Last but not least, the focus lies in the microscopic derivation of the carrier-phonon coupling which is then used for a realistic modeling of the carrier-phonon. In the nano-crystal case, phonon modes are obtained using a microscopically motivated. With these, the coupling strengths of the carrier-phonon interaction are calculated using the wave functions obtained from the k.p theory. The results of the macroscopic model are also used to perform the simulations of the dynamics of the system in a realistic model of a specific nano-crystal. The dynamics include interactions