Inter-sublevel transitions in single InAs/GaAs quantum dots

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In the past, inter-band transitions in quantum dots (QDs) have received an appreciable amount of scientific interest. However, inter-sublevel transitions have been studied much less extensively, likely because of their strongly non-radiative nature and because of limited availability of tunable sources for resonant excitation. In this work we explore the dynamics of inter-sublevel transitions in single InAs/GaAs self-assembled QDs. We combine the commonly used micro-photoluminescence (PL) technique with time-resolved detection and additional excitation by a free-electron laser. The experiment is carried out in the following way: the low-density QD sample is illuminated with a picosecond pulsed Ti:sapphire laser. PL from a single QD is coupled into a spectrometer, recording the spectrum with a CCD detector, as well as the time-resolved transient via the time-correlated single photon counting technique. Introducing a free-electron laser pulse tuned to the inter-sublevel transition energy excites carriers to a higher energy level, which decay back to the ground state non-radiatively with a relatively short time constant. These inter-sublevel dynamics causes quenching in the exponential PL decay of the energy of the ground state, which can be observed in time-resolved measurements. Whereas previous studies on inter-sublevel transitions have used QD ensembles[1-3], investigating single dots excludes many-dot effects such as inhomogeneous broadening and inter-dot transfer, which should lead to a better understanding of inter-sublevel carrier dynamics.

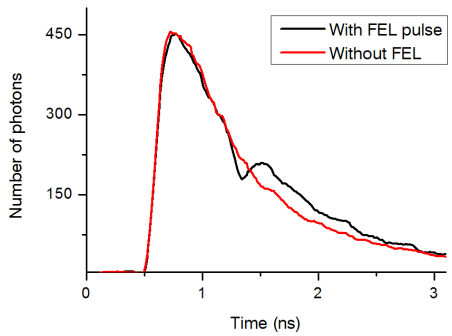

Fig. 1: Transients of the ground state PL line of a single QD, with and without free-electron laser (FEL) excitation. The measurement was taken at 5K with the FEL tuned to 87µm (14meV).

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