Many-body interactions evidenced through exciton-trion-electron correlated dynamics.

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Modulation-doped quantum wells provide a system in which electrons, excitons and trions share the same space, both in real and in reciprocal space. Therefore, we use this model system to investigate the many-body interactions among excitons, trions and electrons through the nonlinear dynamical properties of the excitonic complexes in modulation-doped CdTe QW.

We present novel results that reveal how the nonlinearities induced by trions are different from those induced by excitons, and also that they are mutually correlated. The main source of these differences is attributed to Pauli exclusion-principle. The correlated behavior of excitons and trions manifests itself by crossed trion-exciton effects. We observe phase-space-filling effect for resonantly created excitons as a bleaching of the trion transition, while an induced absorption of excitons is detected when trions are excited on resonance. The latter result strongly suggests that excitons are more dynamically screened by free electrons than by trions. For resonantly created excitons, a blue-shift of the excitonic transition is observed due to repulsive exciton-exciton interactions while no energy shift is seen at the trion line when trions are generated on resonance. This result evidences the significance of the exciton-exciton and trion-trion interactions. In contrast, as excitons are created, the trion resonance undergoes a red-shift, which we attribute to short-range exciton-electron interactions. We find that, at 5 K, trions are formed from excitons within 10 ps; at 20 K a thermal equilibrium is reached within 5 ps.

Our results yield new insight on many-body effects of excitonic complex interactions taken into account the presence of electrons, excitons and trions.

These results were obtained as a function of temperature and densities of excitons, trions and electrons. We use time and spectrally resolved ps-pump and fs-probe experiments. We pump either at exciton or at trion resonance and probe the reflectivity spectra at different times.