TRIONS IN CdTe/CdMgTe QUANTUM WELLS IN HIGH MAGNETIC FIELDS TO 87 T

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Introduction

Magneto-optical spectroscopy is a powerful tool for studying $X^*$ trions – charged three-particle complexes containing two electrons and one hole. Such complexes have two sets of states – singlet, with opposite electron spin alignment, and triplet, with parallel electron spins. It has been shown theoretically (e.g., [1]) and experimentally (e.g., [2]) that both singlet and triplet trion states increase their binding energies in magnetic field. Moreover the triplet state is unbound in the absence of a magnetic field. Thus application of an external magnetic field allows clear observation of the entire set of singlet and triplet trion states in optical spectroscopic experiments.

Experimental

In our earlier experiment [2] we have measured photoluminescence (PL) and reflectivity spectra of a 10 nm wide CdTe/Cd$_{0.7}$Mg$_{0.3}$Te modulation-doped single quantum well containing 2D electron gas of a moderate density ($n_e \sim 3 \times 10^{10}/cm^2$) in a magnetic field up to 45T at 1.6K, 4.2K, and 15K. Those measurements allowed us to classify the observed spectral signatures of singlet, as well as dark and bright triplet trion states. In our latest experiment we have performed PL measurements of a similar quantum well structure in magnetic field up to 87 T at liquid helium temperatures. Figure 1 (a) shows a set of PL spectra in magnetic field from 0 to 55 T in $\sigma^-$ circular polarization, Figure 2 demonstrates a PL spectra in the same polarization at the peak field of 87 T. These data were taken in the 60 T Long-Pulse magnet and the 100T Multi-Shot magnet, respectively. The acquired PL spectra have confirmed the conclusion about the kinetic nature of the trion states behavior made in our previous study: with increasing magnetic field the singlet trion state $T_s$ is suppressed meanwhile the dark triplet state $T_d$ is promoted and becomes one of the dominating lines in the PL spectra due to spin-dependent trion formation mechanism [2]. In our previous research we have been able to observe the bright triplet trion state $T_b$ only as a shoulder to the neutral exciton line $X$. Here, at a very high magnetic field (>50 T) the bright triplet trion state $T_b$ is observed as a separate spectral line. This is in agreement with theoretical calculations of the binding energy dependence of this state on magnetic field (e.g. [1]). Measurements of the trionic PL at a magnetic field as high as 87 T have been performed for the first time. Such experiment at an unprecedented magnitude of the magnetic field gives valuable information on the binding energy field dependences of all the observed states and could be used to verify binding energy calculations in the high field limit.

References