Fine Structure of Trions in High Magnetic Fields Studied for ZnSe and CdTe QWs

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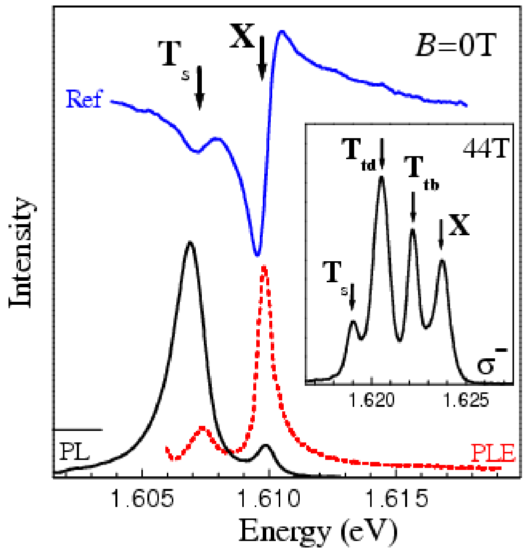
We present detailed studies of negatively charged excitons (trions) in high magnetic fields. Photoluminescence (PL) and reflectivity spectra were recorded in pulsed magnetic fields up to 50 T at the National High Magnetic Field Laboratory, Los Alamos. PL and PL excitation (PLE) spectra were measured in *dc* magnetic fields up to 33 T at the High Field Magnet Laboratory, Nijmegen. The structures studied are ZnSe- and CdTe-based quantum wells (QWs) of various well widths. Modulation doping provides a diluted 2D electron gas in the QWs with a density varied from 5×10^9 to 8×10^{10} cm^{-2}.

At zero magnetic field two lines are observed in emission spectra. The identification of this doublet is quite standard. The high-energy line is ascribed to neutral excitons (X), while the low-energy line is attributed to the singlet state of trions (T_s). In magnetic fields the excitonic resonance splits into several narrow lines, which are clearly resolved in both ZnSe and CdTe QWs (see figure). Based on systematic analyses of polarization in PLE and reflectivity spectra the new lines are identified as "bright" and "dark" triplet states of the charged exciton (T_{tb} and T_{td}) [1,2].



In CdTe QWs we were able to identify a crossing of the lowest triplet state T_{td} and the singlet state at a magnetic field of 24 Tesla, at which point the dark triplet state becames the ground state of the trion. This state is thermally populated and its emission intensity increases at the expense of the singlet state emission. However, the crossing is hidden when we analyze the energies of the optical transitions. Namely, the singlet emission has the smallest photon energy in the whole range of the fields up to 50 Tesla, but it is not the lowest energy state of the trion in the fields above 24 Tesla. The reason is in different Zeeman contributions to the optical transitions of the triplet and singlet states. Taking this fact into account we have restored the "real" (i.e. initial) energies of all states (X, T_s, T_{tb}, T_{td}) directly from the experimental data.

The reported data results from collaboration with D.R. Yakovlev, V.V. Rudenkov, P.C.M. Christianen, S.A. Crooker, W. Ossau, J.C. Maan, G. Karczewski, T. Wojtowicz, J. Kossut, A.B. Dzyubenko, and A. Waag.

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[2] A.Wojs, J.J.Quinn, and P.Hawrylak, Phys. Rev. B **62**, 4630 (2000).