Photoluminescence of p-doped quantum wells with strong spin splitting

H. Boukari[1], P. Kossacki[1;2;3], M. Bertolini[1], D. Ferrand[1], J. Cibert[1,4], S. Tatarenko[1], J.A. Gaj[2], B.Deveaud[3], V.Ciulin[3],
1 *Nanophysique et Semiconducteurs group,* CEA-CNRS-Université J. Fourier Grenoble, Laboratoire de Spectrométrie Physique, BP87, F-38402 St Martin d'Hères cedex, France.
2 *Institute of Experimental Physics, Warsaw University,*
Hoza 69, PL-00-681 Warszawa, Poland
3 *Institute of Quantum Electronics and Photonics,*
Ecole Polytechnique Fédérale de Lausanne (EPFL), CH-1015 Lausanne, Switzerland
4 *Laboratoire Louis Néel, CNRS, BP166, 38042 Grenoble cedex 9, France*

It is almost 50 years ago that charged excitons (trions) have been predicted [1], more than 10 that they have been observed [2] - and still there are some open questions. In the presence of a very low carrier density, it is well established that optical transitions occur from trions in the singlet state (the two identical particles having opposite spin) while triplet configurations (the two identical particles having the same spin) have only been considered in high magnetic fields [3]. When increasing the carrier density, it is accepted that excitons and trions disappear in favor of transitions that are described in terms of an electron-hole continuum, with correlations leading to the formation of a Fermi edge singularity. We report here on new results obtained thanks to the fact that the competition between excitonic complexes and the electron-hole continuum can also be tuned by a spin splitting.

We discuss the optical transitions observed in modulation p-doped (Cd,Mn)Te quantum wells, focusing on photoluminescence. We use the unique possibility of this system to make the so called giant Zeeman splitting larger than several characteristic energies of the system, in magnetic fields small enough to avoid the formation of Landau levels. Different sample designs have been used, in order to change the doping, or even to continuously control the carrier density either optically or by applying a bias in p-i-p and p-i-n diode structures.

At small spin splitting, transmission and photoluminescence transitions involve the positive trion in its singlet state (X_s^+), even at a carrier density as high as 5×10^{11} cm^{-2}. When the spin splitting exceeds a binding energy of about 3 meV – regardless of the hole density - the photoluminescence exhibits a double line. We ascribe the destabilization of the X_s^+ to a crossing of its singlet state with another state where all holes have the same spin orientation. We discuss the nature of the double line, which is related to band to band transitions that are either direct or indirect in **k**-space. A fine analysis of the different states involved makes it possible to measure the spin splitting needed to fully polarize the 2D hole gas, and we show that a complete understanding implies going beyond a one particle image. Finally, we point out that photoluminescence processes may leave the hole gas either in its ground state, or in excited states which still have to be analyzed in details.

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