Internal Transitions of Charged Excitons in AlGaAs/GaAs Lateral Fluctuation Quantum Dots

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We describe magneto-photoluminescence (magneto-PL) and optically detected resonance (ODR) spectroscopy experiments on interface fluctuation quantum dots in the GaAs/AlGaAs system. The goal of these studies is to elucidate the excited states of excitons and the coupling of the center-of-mass and relative motion in the weak lateral confining potential. The experiments are carried out on samples maintained at low temperature in a variable temperature optical-access superconducting magnet (10T) system in conjunction with a grating spectrometer/cooled-CCD system. We report studies of 5 different width $Al_{0.3}Ga_{0.7}As$/GaAs quantum wells (QWs) (2.8 – 14.1 nm) grown by molecular beam epitaxy in a single sample, and doped in the barriers with Si donors to allow for photoluminescence (PL) of both excitons and trions. We have observed single dot PL from the narrowest QW, and we have observed and studied the ODR spectra associated with the ensemble PL of all of the wells. The ODR technique allows us to measure very sensitively resonant absorption of far-infrared (FIR) photons via small changes in the observed PL of the quantum dot ensembles. The internal transitions of excitons and trions are tuned into resonance with the FIR photons by the applied magnetic field. We have observed both singlet and triplet internal transitions of mobile trions, and electron cyclotron resonance in the wider wells. The two narrowest wells do not show any clear evidence of free electron CR, which is expected if the electrons (and excitons) are predominantly trapped in dots. In addition, there is clear evidence in the wider wells of bound-to-bound triplet transitions, which appear on the high-field side of electron cyclotron resonance, and which are strictly forbidden by magnetic translational invariance. These transitions, which have not previously been reported, can be seen because magnetic translational symmetry is broken by the lateral fluctuations, whose characteristic dimensions are greater than the trion orbit size [1]. Results are compared with our previous work on quantum wells, and with a theoretical model that captures the essential physics. Preliminary work on ODR of single dots will also be discussed.

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[1] A.B. Dzyubenko and A. Yu. Sivachenko, Physica E 6, 226 (2000)